P578

PHYSICS ABSTRACTS

SECTION A

of

SCIENCE ABSTRACTS

SECTION A, PHYSICS

SECTION B, ELECTRICAL ENGINEERING

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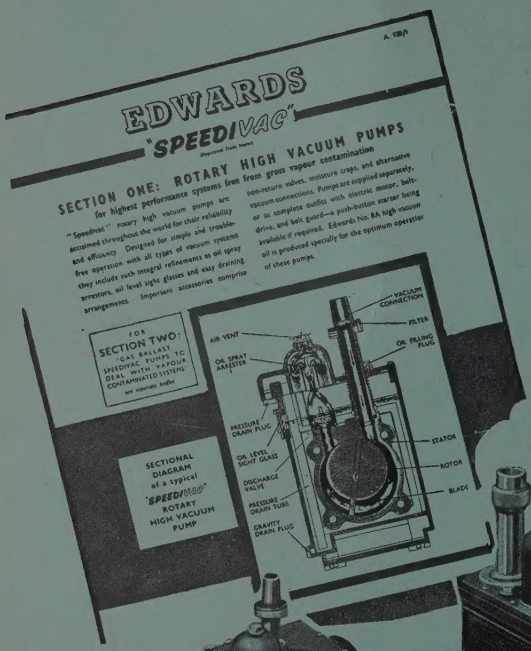

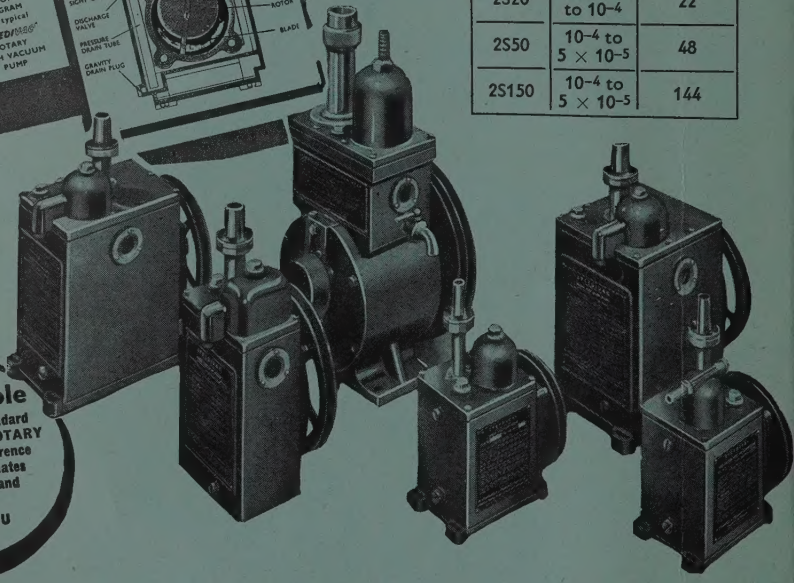

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Principal Contents

FEBRUARY 1955

		PAGE
51	MATHEMATICS	85
52	ASTRONOMY. ASTROPHYSICS. GEODESY	85
53	PHYSICS	88
530.1	Fundamentals	88
531	General mechanics. Mechanics of solids	96
531.7	Mechanical measurements	97
532	Mechanics of fluids	97
532.6	Capillarity	98
532.7	Molecular theory of liquids	98
533	Mechanics of gases	99
533.7	Molecular theory of gases	100
534	Vibrations. Acoustics	100
535	Optics. Radiation. Spectra	103
536	Heat	112
536.7/.8	Thermodynamics	115
537	Electricity	116
537.2	Electrostatics. Dielectrics	116
537.3	Electric conduction. Currents	118
537.52	Electric discharges	123
537.531	X-rays	124
537.533/.534	Cathode rays. Positive rays	124
537.54	Discharge tubes. Counters	127
537.56/.58	Ionization. Thermionics	127
537.591	Cosmic rays	129
538	Magnetism	132
538.3/.5	Electromagnetism. Electrodynamics	135
538.56	Electromagnetic waves and oscillators	136
539.1	Molecular and atomic structure	137
539.11	Theory of solid state	137
539.13	Molecules	138
539.15	Atoms. Nucleus. Isotopes	142
539.16	Radioactivity. α-, β- and γ-rays	145
539.17	Nuclear reactions	150
539.18	Atom and molecular beams. Mesons. Neutrons	157
539.2	Structure of solids	162
539.3/.8	Elasticity. Strength. Rheology	168
541	PHYSICAL CHEMISTRY	169
541.11/.12	Phase equilibrium. Chemical reactions	169
541.13	Electrochemistry	170
541.14/.15	Photochemistry. Radiation chemistry	173
541.18	Dispersions. Colloids. Adsorption	174
541.2/.6	Chemical structure	174
543/545	Chemical analysis	175
548	CRYSTALLOGRAPHY	175
548.7	Atomic and X-ray crystallography	175
55	GEOPHYSICS	178
551.5	Atmosphere. Meteorology	180
57/59	BIOLOGY	185
61	Medical science. Human physiology	185
62/69	TECHNIQUE. MATERIALS	187
77	Photography	187

RELATED SUBJECTS CONTAINED IN SECTION B (ELECTRICAL ENGINEERING ABSTRACTS)

Electrical and magnetic measurements and instruments
Electronic relays and counters
Automatic control mechanisms
Applied electrochemistry
Lines and networks
Waveguides
Photocells
Thermionic tubes
Cathode-ray tubes
X-ray tubes
Oscillators. Pulse circuits
Amplifiers
Electroacoustic apparatus
Radiocommunication
Mechanical engineering
Illumination

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Volume 56 (1953) and the Supplements published with the Indexes to Volumes 56 (1953) and 57 (1954). Reprints of the List of Journals (1953) and the Supplements (1953 and 1954) can be obtained from the Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s. 0d. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

Radiotekhnika	*Radiotekhnika.* Chistoprudnȳi bul'var 2, Moscow.
Regelungstechnik	*Regelungstechnik.* [Article reprinted in *Entwicklungsber. Siemens & Halske.*]
VDI Z	*VDI Zeitschrift.* Formerly *Zeitschrift des Vereines deutscher Ingenieure* [*Z. Verein. dtsch. Ingen.* [*VDI*].]
Z. Verkehrsicherh.	*Zeitschrift für Verkehrssicherheit.* [Article reprinted in *Entwicklungsber. Siemens & Halske.*]

Note

Z. Verein. dtsch. Ingen. [*VDI*]	Title changed to *VDI Zeitschrift* [*VDI Z*] starting with issue dated *January*, 1955.

Erratum

Abstr. 488 (1955), line 7: *for* of the nuclear surface *read* at the nuclear surface.

Corrections to Articles

Corrections have been published, as shown below, to the articles whose abstract numbers are given. Unless otherwise stated, the volume and page given refer to the journal named in the abstract, i.e. the journal in which the original article was published.

Abstr. 967 (1954): **50**(A) *No.* 9–10, 215 (*Sept.–Oct.*, 1954).
Abstr. 3955 (1954): **22,** *No.* 11, 1949 (*Nov.*, 1954).
Abstr. 8574 (1954): **26,** *No.* 4, 472 (*Oct.*, 1954).
Abstr. 9220 (1954): **22,** *No.* 12, 2099 (*Dec.*, 1954).
Abstr. 9406 (1954): **25,** *No.* 12, 1553 (*Dec.*, 1954).
Abstr. 10801 (1954): **26,** *No.* 4, 472 (*Oct.*, 1954).
Abstr. 588 (1955): **22,** *No.* 12, 2099 (*Dec.*, 1954).

MATHEMATICS 51

512.393

683. Solution of cubics and quartics. A. C. Sim. *Wireless Engr*, **31**, *No.* 11, 294–300 (*Nov.*, 1954).

A routine for the determination of the roots of cubic equations is developed specifically to meet the requirements of circuit designers. The method is based upon that used by Emde and is organized so that the solutions are developed with minimum effort. Three significant figures can be obtained using a slide-rule for the subsidiary computations. Ferrari's method for reducing a quartic equation is utilized to develop a similar routine to determine the quadratic factors. Simple checks are provided at appropriate stages in the routines, and a few numerical examples are included. A collection of cubic and quartic Laplace Transforms is appended. A.

518.5

684. An autocorrelogram computer. G. Revesz. *J. sci. Instrum.*, **31**, *No.* 11, 406–10 (*Nov.*, 1954).

A comparatively simple and inexpensive instrument capable of computing autocorrelation functions is described. It was built for the analysis of irregularity in yarn, roving and slivers in the textile industry, but it should find application in a much wider field in cases where the high accuracy of the expensive precision computer is not required. The instrument also lends itself to the computation of cross-correlation functions. Principles of operation and construction are given together with data on performance. The yarn irregularity is recorded on a magnetic tape as a frequency-modulated signal and use is made of a modified d.c. watthour meter for carrying out the multiplying and integrating operations. A.

519.2 : 537.591.15

685. Age-dependent branching stochastic processes in cascade theory. A. T. Bharucha-Reid. *Phys. Rev.*, **96**, *No.* 3, 751–3 (*Nov.* 1, 1954).

A brief introduction to the recent Bellman–Harris theory of branching stochastic processes is given in the nomenclature of cascade theory; and a simple model in cascade theory formulated as an age-dependent branching process is given. A.

ASTRONOMY . ASTROPHYSICS . GEODESY 52

521.042 : 530.162

686. On the frequency of the chemical elements. G. Bussetti. *Nuovo Cimento*, **12**, *No.* 5, 769–79 (*Nov.*, 1954) In Italian.

The formulae of statistical thermodynamics, obtained taking count of the relativistic energy of the particles and of the creation of pairs, are applied to the investigation of the distribution in the universe of the chemical elements, assuming that the elements have been formed in conditions sufficiently near those of thermodynamical equilibrium, as to justify the assumption of the approximate validity of these formulae. Starting from the attempts to deduce from a thermodynamical theory the observed distribution of elements, one finds that agreement with the observational data is obtainable only for densities $\rho \gtrsim 10^{13}$ g/cm^3; moreover one obtains an upper limit for the total mass $m \lesssim 10^{35}$g, in agreement with the astrophysical data concerning the stellar masses. A.

523.11 : 523.161

687. The expansion of a semi-infinite gas-cloud into a vacuum. R. C. Khare. *Z. Astrophys.*, **35**, *No.* 2, 115–24 (1954).

The investigation into the motion of a semi-infinite gas-cloud bordering on a vacuum which was initiated by Burgers, modified by McVittie and Copson, and generalized by Khare has been made *ab initio* in this paper. Without the introduction of the Riemannian Invariants and the complex assumptions in Copson's paper, it has been shown directly that in the case of all gases for which $(\gamma > 1)$, the face of the gas cloud moves into the vacuum eventually with a velocity $2/(\gamma - 1)$ times that of sound in gas at rest. The boundary dividing the stationary and the moving portions of the gas shifts back into the gas at rest with a constant velocity equal to that of sound in stationary gas. These results tally with those obtained in the previous investigations. Initial discontinuities in density and velocity at the face of the cloud in Burgers's work which led to McVittie's paper, as pointed out by Pack, are shown to be absent in the present solution. Further, this paper gives one solution of the differential equations which holds for all real gases, whereas in the previous investigations which used Riemannian Invariants, different solutions were obtained for integral and non-integral values of $n = -(\gamma - 3)/[2(\gamma - 1)]$ where γ is the ratio of specific heats. A.

523.11 : 523.161

688. The expansion of an interstellar gas-cloud—viscosity taken into account. R. C. Khare. *Z. Astrophys.*, **35**, *No.* 2, 125–34 (1954).

This paper deals with the unilateral expansion of an interstellar gas-cloud into vacuum. The cloud extends from $x = h$ to $x = \infty$. There is vacuum for $x \leqslant h$. A layer of inhomogeneous gas at the front is backed by homogeneous gas extending to ∞. The motion starts due to difference of pressure in the inhomogeneous region. Heat conduction and radiation pressure have been neglected while viscosity has been taken into account. The coefficient of viscosity has been taken to be constant. The pressure and density are taken to be related by the law $p = k\rho^\gamma$. The expansion has been assumed to be polytropic and isentropic. It has been shown that for the gas where $\gamma = 3$, the motion remains unaffected by viscosity. The face of the cloud moves into vacuum eventually with the constant velocity equal to that of sound in

gas at rest. The boundary which separates the stationary from the moving portion of the gas shifts back into the stationary region with the constant velocity equal to that of sound. There is no discontinuity in the motion at any time. It is interesting to note that for $\gamma = 3$, the velocities of the front of the cloud and the inner boundary in Khare's paper reduce to the values obtained in the present paper. This confirms the conclusion that the motion in the present case is unaffected by viscosity. A.

523.162.2

689. On the interpretation of the extragalactic red-shifts. G. J. WHITROW. *Monthly Not. Roy. Astron. Soc.*, **114**, *No.* 2, 180–90 (1954).

A new criterion is obtained, independent of any particular choice of world-model, for helping to decide between the recessional and non-recessional hypothesis concerning the extragalactic red-shifts. It is found that the shift-distance law takes the same form for any non-recessional hypothesis, provided that there is a definite correlation between shift and distance which is independent of time, whereas a wide variety of laws are compatible with the recessional hypothesis. When the assumption that the shift-ratio of the spectrum of a typical galaxy is independent of wavelength is relaxed, more general formulae are obtainable. A.

523.165

690. Radiation from the galaxy and supergalaxy at 250 megacycles per second. J. D. KRAUS. *Astron. J.*, **59**, *No.* 3, 113–16 (*April*, 1954).

A survey of the radiation in the Centaurus–Virgo–Coma Berenices–Ursa Major region reveals an extended radio source of low brightness that corresponds approximately in position to the equatorial plane of the supergalaxy. Graphs are presented in which the position of the radio source is compared with contours based on the distribution of the Shapley–Ames galaxies. A.

523.165

691. The isotropic component of cosmic radio-frequency radiation. J. R. SHAKESHAFT. *Phil. Mag.*, **45**, 1136–44 (*Nov.*, 1954).

Attempts have been made to interpret the observed galactic radio emission in terms of the integrated radiation from sources having a spatial distribution similar to that of the common optical stars. It is found, however, that such models fail to explain the large intensity observed towards the direction of the galactic poles. The origin of this additional component is discussed and the two most probable explanations seem to be (*a*) the incidence of an isotropic component from extra-galactic sources, and (*b*) the existence of a new class of object having a wide spatial distribution relative to the galactic plane. The integrated radiation from normal extra-galactic nebulae is shown to be inadequate to account for the observations. An estimate has been made of the intensity likely to be produced by sources of the type associated with the collision of two galaxies, and it is shown that such sources will increase significantly the emission per unit volume. An independent figure can be derived from data on the large scale irregularities in the distribution of galaxies. The total intensity to be expected from extra-galactic sources is found to depend strongly on the more distant regions of the Universe, and the value obtained, therefore, depends on the Cosmological theory adopted. Accurate measurements of the extra-galactic component might thus be important in distinguishing between different theories. It is possible to account for the observed polar intensity with extra-galactic sources using Relativistic Cosmology, but not on the Steady-State theory. Recent measurements of the Andromeda nebula have, however, suggested that part of the polar emission may be due to galactic sources and a conclusive distinction cannot therefore yet be made. A.

523.165 : 551.510.535

692. Effects of solar flares on the absorption of 18·3 Mc/s cosmic noise. C. A. SHAIN AND A. P. MITRA. *J. atmos. terrest. Phys.*, **5**, *No.* 5–6, 316–28 (*Nov.*, 1954).

Two effects of solar flares on the received intensity of 18·3 Mc/s cosmic noise are discussed. It is shown that observations of the variations in 18·3 Mc/s cosmic noise intensity provide a very sensitive method of detecting sudden ionospheric disturbances (SIDs). The characteristics of the increases in absorption observed during SIDs are discussed and comparisons made with other SID observations, particularly very long wave sudden phase anomalies. It is shown that an increase of 1 db in the absorption of 18·3 Mc/s radiation passing once through the ionosphere is probably associated with a sudden phase anomaly of size about 200 degrees at 16 kc/s. Such a relationship is incompatible with a *D*-region of the simple Chapman type or one of the "exhaustion region" type. About 30 hours after certain solar flares of Class 3 the absorption of cosmic noise increased, the increase lasting for periods of the order of 10 hours. Magnetic storms did not follow until some time later and at the time of the abnormally high attenuation there were no outstanding peculiarities in magnetic records. It is uncertain whether the excess attenuation occurs within the ionosphere or well away from the earth. A.

523.47/.48 : 541.123.2

Metallic ammonium as possible constituent of planets. *See Abstr.* 1307

523.53

693. The two-helix method for polarization measurement of meteoric radio echoes. M. E. VAN VALKENBURG. *J. geophys. Res.*, **59**, *No.* 3, 359–64 (*Sept.*, 1954).

A method employing two helical-beam aerials is described for measuring polarization effects of radio echoes from non-shower meteors of unknown trial orientation. Results obtained by the method are in good agreement with theoretical values and with measurements made on shower meteors by another method by Clegg and Closs. A.

523.53

694. The Quadrantid meteor shower. P. M. MILLMAN AND D. W. R. MCKINLEY. *J. Roy. Astron. Soc. Canada*, **47**, *No.* 6, 237–46 (*Nov.–Dec.*, 1953).

Radio observations of the 1951 Quadrantid meteor shower yield a mean geocentric meteor velocity of $40{\cdot}9 \pm 0{\cdot}5$ km/sec. The observed duration of the

shower was five hours. Using the radio determinations of velocity and time of peak activity, together with a mean radiant position based on data from other sources, an orbit has been computed. The eccentricity of this orbit is 0·74, the inclination 70°, and the period 7·2 years; hence it is similar to the orbits of other meteor showers and short period comets. A.

523.53

695. Radio echo observations of the day- and night-time meteor streams 1951 October to 1953 December. K. BULLOUGH. *Jodrell Bank Ann.*, **1**, *No.* 3, 68–97 (*June*, 1954).

Factors influencing the observed hourly rate of shower meteors are discussed. Mean ephemerides have been computed for the daily motion of the Arietid, Perseid, Taurid, Quadrantid, Perseid and Geminid radiants. On Jan. 3, 1953, the Quadrantid hourly rate at transit was two to three times that usually observed, indicating a condensation in the stream. A.

523.77

696. On the interpretation of the contours of strong Fraunhofer lines. S. MIYAMOTO. *Z. Astrophys.*, **35**, *No.* 3, 145–58 (1954).

Doppler core and inner wind contours of strong Fraunhofer lines have been investigated. Theoretical bases used for the interpretation of observations are coherent and non-coherent formulae. Doppler widths of strong lines are very much reduced by the fluorescence emission, which is responsible for the high residual intensity of strong lines. The quanta created at the line centre by fluorescence escape through the less opaque frequency regions on both sides of the line centre. This effect acts to reduce the apparent Doppler width. Observed widths are interpreted to indicate a turbulence as large as 4 km/sec at the upper photosphere, where the Doppler cores of the strongest Fraunhofer lines are formed, increasing from the weaker turbulence comparable with the thermal motion of metallic elements at the lower photosphere, where faint lines originate. The non-coherent contour predicts a flat part just outside the Doppler core. The intensity of this flat part depends upon the parameter β relating to the temperature distribution in the photosphere, and shows a centre limb variation. Theory was compared with observations. As a representative of the strongest neutral metallic lines, Houtgast's observation of Mg b_1 was selected, and it was attempted to fit it with the non-coherent and coherent formulae. It has been shown, by numerical trials, how the inner wing contours and its centre limb variation depend on the model of the photosphere, and on the mode of scattering process. A.

523.77

697. Further measurements to detect a general magnetic field of the sun. H. VON KLÜBER. *Monthly Not. Roy. Astron. Soc.*, **114**, *No.* 2, 242–5 (1954).

The attempts made in 1949 to detect a general magnetic field of the sun by an interferometric method were continued at the Cambridge Observatories during 1950, again supposing that the field would be of dipole form, with an axis approximately coinciding with the sun's rotational axis. The results of the measurements of about 700 interference knots are shown. The m.s.e. of a single point is about ± 3 gauss. It is concluded from these measurements that at the time of the observations, in 1950 July–August, such a general field must have been smaller than about 2 gauss and was not detectable by the present method. This is in agreement with the 1949 result. A.

523.851.2

698. A study of the equilibrium of globular clusters. R. V. D. R. WOOLLEY. *Monthly Not. Roy. Astron. Soc.*, **114**, *No.* 2, 191–209 (1954).

Examines the theory of the distribution of density in globular clusters by a method which gives prominence to the velocity distributions of the stars. The technique reproduces standard generalizations by Jeans and Eddington and leads to the well-known "isothermal" distribution when the velocity distribution is Maxwellian and the stars all have the same mass. The general equation for the density and potential is given for any isotropic velocity distribution, where the stellar masses are not all the same. This equation is solved numerically (1) for stars of equal mass, having a "truncated Maxwellian" velocity distribution; (2) for a full Maxwellian velocity distribution, but with the number of stars of mass m proportional to $m^p e^{-bm}$. The solution is then connected with Emden's equation of index $-(p+2)$; and (3) for a truncated Maxwellian velocity distribution with the number of stars of mass m proportional to $m^p e^{-bm}$. The case $p = 1$ is examined in detail and the distributions of the stars of various masses discussed. A.

523.852.22

699. Electron temperatures and electron densities in planetary nebulae. M. J. SEATON. *Monthly Not. Roy. Astron. Soc.*, **114**, *No.* 2, 154–71 (1954).

Electron temperatures T_e and electron densities N_e are estimated from a study of the relative intensities of the forbidden lines in the following nebulae: NGC 7027, 2440, 7662, 6572, IC 418 and Orion. For certain ions (N II, O III, O II and S II) it is possible to measure the relative intensities of two multiplets originating from different metastable terms. Each intensity ratio gives a relation between T_e and N_e. A further relation may be obtained if it is assumed that $N_1(\text{O I})/N_1(\text{N I}) = N_1(\text{O II})/N_1(\text{N II})$, where $N_1(\text{X})$ is the number of ions X in the ground state per cm^3. Recently calculated electron excitation cross-sections enable these various relations to be obtained in numerical form. The observed relative intensities of the forbidden lines are corrected for absorption and systematic calibration errors by comparing observed and theoretical relative intensities in the hydrogen spectrum. Simultaneous solutions for T_e and N_e are then obtained from the forbidden line intensity ratios. The values of T_e range from $1{\cdot}3\times10^4$ to $2{\cdot}0\times10^{4\circ}$K, and the values of N_e from 8×10^3 to 5×10^4 per cm^3. The consistency of the various T_e, N_e relations is particularly satisfactory for NGC 7027, NGC 2440 and IC 418; for the other objects considered the observed intensities tend to be either less reliable or less complete. With the exception of IC 418, the densities obtained from the forbidden lines are greater than those obtained from the surface brightness by a factor of order 3. These differences

are probably a consequence of the densities being non-uniform. The surface brightness method gives essentially a r.m.s. density for the total geometrical volume, while the forbidden line methods give average densities for the active emitting regions (clouds and filaments). Such differences would not be expected for IC 418, which is particularly uniform. In a final section the abundance ratios $N(O)/N(N)$ are estimated to be 1·6, 0·43 and 2·0 for NGC 7027, NGC 2440 and IC 418 respectively. It is concluded that the results reveal a real difference in composition between NGC 2440 and the other two objects. A.

523.855

700. Mass distribution and mass-luminosity ratio in galaxies. M. SCHWARZSCHILD. *Astron. J.*, **59**, *No.* 8, 273–84 (*Sept.*, 1954).

The observational data bearing on the mass distribution and mass-luminosity ratio in galaxies are rediscussed and assembled. The observations on the mass distribution indicate, contrary to earlier suggestions, that the data now available permit the assumption of identical spacial distribution of mass and luminosity. The results for the mass-luminosity ratio are summarized. In agreement with earlier investigations, the elliptical galaxies are found to have a mass-luminosity ratio much larger than that of pure population I systems. The Andromeda nebula is found to have an intermediate mass-luminosity ratio, suggesting that the body of the Andromeda nebula may consist of a mixture of population II and old population I stars. A.

523.877

701. On the intensities of interlocked multiplet lines in the Milne–Eddington model. I. W. BUSBRIDGE AND D. W. N. STIBBS. *Monthly Not. Roy. Astron. Soc.*, **114**, *No.* 1, 2–16 (1954).

The equations of transfer in the Milne–Eddington model for multiplet lines with a common upper state are solved exactly. It is assumed that no redistribution in frequency takes place other than that due to interlocking, that the ratios of the line absorption coefficients to the continuous absorption coefficient are independent of depth, and that the lower states of the lines are sharp. A linear approximation for the Planck function is used. The solution is found to depend on H-functions of a fairly simple type. The case of a doublet is considered in detail. Values for the H-functions are computed and the residual intensities of the two components are evaluated as functions of $\mu(=\cos\theta)$ for three distances from the centres of the lines. These are compared with the residual intensities for doublet lines when there is no interlocking. It is shown that interlocking causes a small reduction in the difference between the residual intensities of the two lines, the reduction being greater towards the limb. A solution for the doublet intensities based on Eddington's approximation is also considered and it is shown that the errors in the approximate solution are satisfactorily small for $\mu > 0{\cdot}2$. A.

525.73

702. Experimental verification of a recently proposed theory of astronomical seeing. G. KELLER AND R. H. HARDIE. *Astron. J.*, **59**, *No.* 3, 105–13 (*April*, 1954).

The theory has been developed in a number of particulars and then subjected to a series of laboratory tests. An artificial star was employed for these tests and turbulence was produced under controlled conditions. Within the precision of the measurements, the experimental results are all in agreement with the theory. In conclusion, it is pointed out that when seeing conditions are good, seeing images observed in red light are somewhat sharper than those observed in blue light. A.

526.72

703. Magnetic perturbations of invar pendulums used for relative gravity measurements. A. H. COOK. *Monthly Not. Roy. Astron. Soc., Geophys. Suppl.*, **7**, *No.* 1, 1–21 (*Oct.*, 1954).

Certain discrepancies in recent relative gravity measurements made with the Cambridge pendulum apparatus may be due to magnetic forces on the invar pendulums. In addition to effects which have been described previously, it is shown that disturbances may arise from a magnetic screen surrounding the pendulums and from the magnetic interaction of two pendulums swinging together. Theoretical estimates of these effects are compared with experiments. The behaviour of the pendulums is qualitatively as predicted but the numerical results are in poor agreement. This may be due in part to the difficulty of making calculations for pendulums with dimensions comparable to their distances from the magnetic screen and each other. The application of the results to gravity measurements is considered. A.

PHYSICS 53

53.08

704. New experimental designs for paired observations. W. J. YOUDEN AND W. S. CONNOR. *J. Res. Nat. Bur. Stand.*, **53**, *No.* 3, 191–6 (*Sept.*, 1954).

There are many experimental situations in which observations naturally occur in pairs. From v quantities to be compared, $v(v-1)/2$ distinct pairs can be formed, so that for even moderately large v, the accompanying number of observations may be prohibitively large. Or, even if the work can be done, the precision of the estimates of the effects of the quantities and the experimental error may be greater than is needed. In either event, a subset of the pairs should be used. If the arithmetic is to be manageable, this subset must be chosen with care. Such a subset is described and its analysis is given in detail. A.

FUNDAMENTALS 530.1

530.12

705. On the motion of bodies in general relativity theory. L. INFELD. *Acta phys. Polon.*, **13**, *No.* 3, 187–204 (1954).

The object of this paper is to give a simple derivation

of the non-Newtonian equations of motion following from the field equations in general relativity theory. This is achieved through the use of Dirac's δ functions in the energy-momentum tensor. All calculations (with the exception of the most trivial ones) are included. A.

530.12

706. On static solutions of Einstein's generalized theory of gravitation. I. M. IKEDA. *Progr. theor. Phys.*, **12**, *No.* 1, 17–30 (*July*, 1954).

In Einstein's generalized theory of gravitation, the expressions of the basic quantity of the electromagnetic field are clarified and "field strength" is defined so as to introduce "four-vector potential." When the distribution of matter and charge is static and spherically symmetric, it is possible to choose, by using the electrostatic potential, a suitable boundary condition independently of the co-ordinate system used and to overcome the difficulty of Wyman and others. The asymptotic behaviour of Wyman's solution is studied and the resulting forms are found to be satisfactory. The mutual effect of matter and charge is also discussed and the results are compared with those of general relativity for a point charge. A.

530.12

707. Mach's principle and unified field theory. J. CALLAWAY. *Phys. Rev.*, **96**, *No.* 3, 778–80 (*Nov.* 1, 1954).

An argument based on the impossibility of satisfying Mach's principle within general relativity is given which leads to the idea of unified field theory. A possible alternative is discussed. A.

530.12

708. Note on the Whitehead–Rayner expanding universe. J. L. SYNGE. *Proc. Roy. Soc. A*, **226**, 336–8 (*Nov.* 23, 1954).

Rayner [Abstr. 4151 (1954)] obtained the fundamental form of an expanding universe on the basis of Whitehead's gravitational theory. In this note a rather simpler equivalent form is derived in a much simpler way. A.

530.12

709. The equations of motion in the non-symmetric unified field theory. W. B. BONNOR. *Proc. Roy. Soc. A*, **226**, 366–77 (*Nov.* 23, 1954).

The field equations of the non-symmetric unified theory of gravitation and electromagnetism are changed so that they imply the existence of the Coulomb force between electric charges. It is shown that the equations of motion of charged masses then follow correctly to the order of approximation considered. The equations for weak fields in the modified theory are derived and shown to lead to Maxwell's equations together with a restriction on the current density. This restriction is different from that in the original theory, and in the static, spherically symmetric case permits a charge distribution more likely to correspond to a particle. The failure of the original theory to lead to the equations of motion is related to the structure of the quantities appearing in it, and reasons are given for supposing that no non-symmetric theory simpler than the one put forward is likely to give these equations in their conventional form. A.

530.12 : 517.5

710. Determination of the Lorentz-invariant structure of the Green function of the so-called general wave equation by means of Faltung operations in Minkowski space and its Fourier space. R. HOSEMANN AND S. N. BAGCHI. *Z. Phys.*, **139**, *No.* 1, 1–29 (1954) In German.

Function complexes and function algebra established in two earlier papers [Abstr. 1007, 8019 (1954)] are extended to space-time and the new methods are used to study the Green function for the equation $\Box\psi - k\psi = 0$ where $k \geqslant 0$. The function is determined in terms of functions defined on and within the retrograde cone and the method avoids divergence difficulties arising in other treatments of the Cauchy boundary value problem. R. A. NEWING

530.145

711. On time reversal. G. MORPURGO, B. F. TOUSCHEK AND L. A. RADICATI. *Nuovo Cimento*, **12**, *No.* 5, 677–98 (*Nov.*, 1954).

It is pointed out that a satisfactory definition of time reversibility in quantum theory has not yet been given, so that for example the reasons for the exclusion of a system as irreversible are somewhat obscure. In this paper a definition of reversibility is given, which takes account of the fact that a system may be described by a whole set of equivalent Hamiltonians. Such a definition therefore excludes irreversible systems and not one Hamiltonian which might still be one of a set of Hamiltonians some of which are reversible according to the old set of prescriptions. The definition is suggested by the correspondence principle and based entirely on the transformation properties of observable quantities. It is found that the new formulation is sufficient to exclude systems whose Hamiltonians had hitherto been labelled as irreversible—though the method of demonstration—owing to the generality of the postulates—is somewhat more complicated than the usual one. A.

530.145

712. General theory of propagators. II. H. UMEZAWA AND A. VISCONTI. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 13, 749–51 (*Sept.* 27, 1954) In French.

For Pt I, see Abstr. 37 (1955). The two-body propagator and renormalization of mass, charge, etc., are considered. G. E. BROWN

530.145

713. Commutation relations between different fields. H. UMEZAWA AND S. ONEDA. Letter in *Nuovo Cimento*, **12**, *No.* 4, 566–7 (*Oct.*, 1954).

Commutation relations between different fields are restricted by the interaction Hamiltonian and hence by the decay schemes. A further restriction in terms of fermion "families" is proposed. P. T. MATTHEWS

530.145

714. On a treatment of many-particle systems in quantum field theory. H. SUURA. *Progr. theor. Phys.*, **12**, *No.* 1, 49–71 (*July*, 1954).

Using the distribution of the virtual particles in the true vacuum and around a real particle, a complete

set of states are defined, each of which may be interpreted as representing a prescribed number of real particles. The representation spanned by this set of states is non-orthogonal and the Schrödinger equation transformed into this representation includes the non-Hermitian interaction Hamiltonian. However, the usual definition of the transition probability can be used also in this representation. The equation has the advantage that the energy of the system appears as the difference from the vacuum energy and that the vacuum or the single-particle self-energy process no longer occurs. An alternative Hermitian equation is also derived, which, applied to the proton-neutron system, gives the non-adiabatic Dancoff potential and the finite single nucleon self-energy term to the second order in the coupling constant. To this order, the divergent vacuum self-energy term reappears, but it is shown to be cancelled by including the contributions of the higher-order terms. The simple relations between the true vacuum state, the real one-particle states and the other unbound stationary states are also deduced. All these formulations may be used to treat the many-particle systems on the knowledge of the solutions of the one-particle systems. A.

530.145

715. Non-perturbative equations for propagation kernels. E. R. CAIANIELLO. Letter in *Nuovo Cimento*, **12**, *No.* 4, 561–2 (*Oct.*, 1954).

In a previous paper [Abstr. 6270 (1954)], equations defining the propagation kernels in theories with linear coupling between fermion and boson fields were derived. The present letter gives single equations for any given kernel, containing derivatives of the kernel with respect to the coupling constant. More information can be obtained from these than from the same type of equations previously given. G. FIELD

530.145

716. The Green's functions of quantised fields. P. T. MATTHEWS AND A. SALAM. Letter in *Nuovo Cimento*, **12**, *No.* 4, 563–5 (*Oct.*, 1954).

Feynman's "sum over paths," in its field theoretic form, expresses the matrix element of a chronological product of operators, between states at different times, as a functional integral over the fields. The integral for the many-nucleon propagator in an external field is evaluated. The complete n-nucleon m-meson propagator for interacting quantized fields is expressed as a functional integral, over the meson field, of the external field propagator and the vacuum to vacuum expectation value. P. T. MATTHEWS

530.145

717. Mass quantization in non-local field theory. J. RAYSKI. Letter in *Nuovo Cimento*, **12**, *No.* 5, 815–16 (*Nov.*, 1954).

By incorporating, in a new way, the supplementary condition in the author's bilocal field theory [Abstr. 3092, 6284 (1954)], a formalism similar to that of Fierz [*Helv. phys. Acta*, **12**, 3 (1939)] is obtained. There is a two-parameter mass spectrum for the meson and nucleon families. Fitting the meson spectrum to the π- and θ-mesons, gives two further mass values at 1260 m_e and 1490 m_e, both of which have been observed. P. T. MATTHEWS

530.145

718. Vacuum polarization in mesonic atoms. A. B. MICKELWAIT AND H. C. CORBEN. *Phys. Rev.*, **96**, *No.* 4, 1145–7 (*Nov.* 15, 1954).

The effects of vacuum polarization on the energy levels of π and μ mesonic atoms are computed to the lowest order for states $1s(Z \leqslant 12)$, $2p(Z \leqslant 30)$, $3d(Z \leqslant 82)$, $4f(Z \leqslant 82)$. If one ignores the finite size of the nucleus, these results may be written explicitly in a closed form. The effect of the finite size of the nucleus is estimated and shown to be $<8\%$ for all states considered. Since the virtual pairs are described here by plane waves, the fractional error in these results is of order $(Z\alpha)^2$. A.

530.145

719. Quantization of multiple frequency linear systems. J. K. PERCUS. *Phys. Rev.*, **96**, *No.* 4, 1147 (*Nov.* 15, 1954).

The commutation relations and constants of motion for a wave equation whose frequencies have a common degeneracy are discussed. Although the quantum relations separate into those of simple subsystems, the corresponding decomposition holds only for a restricted class of constants of motion, excluding the energy. A.

530.145

720. The self-consistent field method for tensor forces. A. S. KOMPANEETS. *Zh. éksper. teor. Fiz.*, **25**, *No.* 5 (11) 540–7 (1953) In Russian.

A modified Thomas–Fermi equation is derived by assuming the 2-particle interaction to contain, in addition to electrostatic forces, a meson interaction of the symmetrical ps. scalar type with tensor forces. The additional terms in the equation correspond to direct and exchange interaction energy densities in the first approximation of the statistical treatment. The solution of the differential equation is not attempted. W. J. SWIATECKI

530.145

721. Relativistically invariant form of electrodynamics without longitudinal and scalar fields. E. M. LIPMANOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 2 (8) 135–41 (1954) In Russian.

The potential $A_\mu(x)$ is split into a dynamical field a_μ and a time-like component ϕ, using a particular gauge which reduces to $\nabla . A = 0$ in the usual reference system. The formulation is carried through both classically and in quantum theory. G. E. BROWN

530.145

722. Note on electrodynamics with higher derivatives. I. KH. KUUSIK. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 2(8) 260–1 (1954) In Russian.

The work of Podolsky and Schwed [Abstr. 2010 (1948)] is in error in maintaining that their subsidiary condition is compatible with the Dirac equation. Alternative subsidiary conditions are mentioned. G. E. BROWN

530.145

723. A formulation of field theory in Hilbert space. G. IWATA. *Progr. theor. Phys.*, **11**, *No.* 6, 537–56 (*June*, 1954).

A formulation of field theory is set up by making use of tensors in Hilbert space and is applied to

quantum electrodynamics. The usual formulation coincides with, as to pair creation, pair annihilation, Compton scattering, and differs from, as to electron self-energy, vacuum polarization, the present formulation in which the electron self-energy diverges while the vacuum polarization never appears. A.

530.145

724. On the field measurements and the state definition in quantum electrodynamics. B. FERRETTI. Letter in *Nuovo Cimento*, **12**, *No.* 4, 558–60 (*Oct.*, 1954).

The question of defining the states of an electromagnetic field, i.e. of performing complete sets of measurements of the field quantities is raised. This is a point not previously discussed in the Bohr and Rosenfeld papers [Abstr. 6996 (1950)] on the measurability of field quantities. The special case of an electromagnetic field without interaction with an electron-positron field is considered. G. FIELD

530.145

725. The proper mass of the photon. A. PRESSMAN. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 17, 1023–5 (*Oct.* 27, 1954) In French.

The group velocity of electromagnetic waves is calculated for a space-time such that $R_{ik} = 3g_{ik}/a^2$. The proper mass associated with a wave packet of energy $h\nu$ is found to be $\sqrt{3}h/2\pi ac$. R. A. NEWING

530.145

726. Direct proof of the covariance of Gupta's indefinite metric in quantum electrodynamics. F. J. BELINFANTE. *Phys. Rev.*, **96**, *No.* 3, 780–7 (*Nov.* 1, 1954).

Gupta's method of the indefinite metric is at this time for many purposes the most satisfactory method of formulating the principles of quantum electrodynamics. Gupta's indefinite metric, however, depends on the number of scalar photons. This number is no invariant. Yet, the covariance of Gupta's indefinite metric has been proved before. This seems at first surprising. The present paper shows why the lack of invariance of the number of scalar photons does not matter and how a certain covariance of the occupation numbers together with "repolarization operators" insures the covariance of Gupta's method. In particular, if the norms of the eigenfunctions of occupation numbers are chosen in accordance with Gupta's prescription in one Lorentz frame, they are automatically in accordance with this prescription in a different Lorentz frame. A.

530.145

727. On the definition of finite operator quantities in quantum electrodynamics. J. G. VALATIN. *Proc. Roy. Soc. A*, **226**, 254–65 (*Nov.* 9, 1954).

Field equations for finite quantized fields are obtained by including a limiting process in the definition of the non-linear terms, generalizing thereby a method of Dirac and Heisenberg. The equations are deduced from an action integral, the compensating terms of which are defined by means of vacuum expectation values of operators. The compensating functions depend on several off-diagonal distances, and are expressed in terms of space-time averages, without reference to Fourier transforms. The concept of renormalization and its possible arbitrariness are discussed. In the determination of finite quantities the use of the commutation relations of incoming free fields is assumed. Since the commutation relations of (renormalized) field quantities, for equal time arguments, are related to infinities for physical reasons, the form of the canonical formalism which relates the concept of a state-vector to a given space-like surface does not seem suitable as a basis for a consistent finite field theory. A.

530.145

728. Some remarks on the charge conjugation. S. TANAKA. *Progr. theor. Phys.*, **12**, *No.* 1, 72–8 (*July*, 1954).

Charge conjugation is represented by a reflection in some space, i.e. the charge space. The discontinuity of this transformation gives rise to some arbitrariness and so several transformation types. Regarding these transformation types as the intrinsic property of the individual elementary particles, the author investigates the possibility of introducing the qualitative difference between elementary particles and the conservation law of heavy particles; more generally, the transition rule between elementary particles would be supported by such a superselection rule as that recently proposed by Wigner *et al.* in association with time reversal. A.

530.145

729. On the renormalization technique in quantum electrodynamics. B. FERRETTI. Letter in *Nuovo Cimento*, **12**, *No.* 3, 457–9 (*Sept.*, 1954).

The renormalization procedure applied previously by the author [Abstr. 2004 (1954)] is simplified, and carried out in closed form. P. T. MATTHEWS

530.145

730. Calculation of potentials from the new Tamm–Dancoff equation. J. C. TAYLOR. *Phys. Rev.*, **96**, *No.* 5, 1438–41 (*Dec.* 1, 1954).

About the construction of energy-independent potentials from the Tamm–Dancoff equations, by a systematic method of Klein's. It is shown that, when the method is applied to the new Tamm–Dancoff equation of Dyson, the difficulty of the spurious singularities can be overcome. It is proved further that the old and new Tamm–Dancoff methods give the same potential in the adiabatic limit. A.

530.145

731. On the question of the mass spectrum of elementary particles. P. G. KARD. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 2(8) 259–60 (1954) In Russian.

If a fifth dimension is considered as the proper time of the particle, and if periodicity of this dimension is required, then the canonically conjugate operator, the self-mass, is quantized. Various self-masses are compared with known masses. G. E. BROWN

530.145 : 537.12

732. Introduction of a fundamental length in the classical theory of the electron. P. CALDIROLA AND F. DUIMIO. *Nuovo Cimento*, **12**, *No.* 5, 699–732 (*Nov.*, 1954) In Italian.

The main difficulties connected with a classical theory of the electron interacting with the electromagnetic field are examined, especially and particularly

those contained in the theories of Abraham–Lorentz and Dirac–Eliezer. Accepting the necessity of the introduction, still in the classical relativistic electrodynamics, of a fundamental length, the authors propose a finite-difference equation, relativistically invariant, which seems to eliminate the above said difficulties. Some applications of this equation to simple problems are discussed and a general Lagrangian formulation of the theory is sketched, in which the methods of Ostrogradski and of Pais–Uhlenbeck are used. The great difficulties of this formulation, which should be the basis for a quantization, are emphasized. A connection between the present theory and others is stated. Finally the authors show how their theory could be inserted in the frame of a general theory of the electromagnetic field interacting with its own sources, in which the mass of the electrons is completely of e.m. nature, without violating the principle of relativity. The last interesting consequence is the possibility of a classical interpretation of the anomalous magnetic moment of the electron, connected with the "microscopical solutions" describing the behaviour of the electron in small regions (of the order of the fundamental length) of space-time. This "internal structure" of the electron could play a very important role in a future quantized theory, where it could perhaps give rise to a mass spectrum of elementary particles. A.

530.145

733. A dynamically deformable form-factor of elementary particles. M. A. Markov. *Zh. éksper. teor. Fiz.*, **25**, *No.* 5(11) 527–39 (1953) In Russian.

Usually form-factors are assumed to be independent of the forces acting on the particle, which is equivalent to the assumption of a perfectly rigid structure (apart from the kinematic Lorentz contraction). The signal velocity inside such a structure is infinite, in contradiction with the principle of relativity. The usual form-factor theories must, therefore, contain hidden inconsistencies which are responsible for their failure; the nature of these is illustrated in the Tomonaga–Schwinger as well as the S-matrix formulations of rigid form-factor theories. The description of a system with a deformable form-factor $F(x)$ leads to the treatment of $F(x)$ as a new field. It is natural to attempt to identify also this field with currently studied fields. From this point of view the Dirac equation for a "free" proton should be regarded as an approximate equation for the motion of the centre of gravity of a distribution of charge, whose form-factor $F(x)$ is the density $\rho(x)$ of e.g. a π-meson field $[\rho(x) = ie(\phi^*\phi - \phi\phi^*)$ for scalar mesons]. The pion field is described by a Klein–Gordon equation which, in turn, contains a form factor $f(x)$ (e.g. $f = \Psi^*\Psi$, where Ψ is the nucleon field). The resulting complicated system of inter-related equations can be approached in a phenomenological way by the use of a simple deformable form-factor. An example is given by taking for it an expression of the type: exp (minus the scalar product of the nucleon and meson wave-numbers). The resulting modification of the differential cross-section $\sigma(E, \theta)$ for the scattering of $\pi^{\pm}$ mesons by a proton is given by a simple function of E and θ, which predicts an eventual decrease of σ with E and, for π^+ (but not π^-), a relatively augmented scattering at large angles. Similar considerations lead to simple predictions regarding the modifications in the photo-production of charged and neutral mesons. W. J. Swiatecki

530.145

734. Transient effects in the penetration of a potential barrier. J. M. Lozano. *Rev. Mexicana Fis.*, **3**, *No.* 2, 63–75 (*April*, 1954) In Spanish.

The dynamical description of nuclear dispersion by means of the S-matrix formalism discussed in a previous paper [J. M. Lozano, *Rev. Mexicana Fis.*, **2**, 155 (1953)] is extended to a study of transient effects. L. Pincherle

530.145

735. The classical equations of a point particle in a symmetric meson field. R. C. Majumdar, S. Gupta and S. K. Trehan. *Progr. theor. Phys.*, **12**, *No.* 1, 31–48 (*July*, 1954).

The equations of motion of a point particle interacting with charge symmetrical mesons are deduced on the action-at-a-distance theory from a variation principle which is analogous to that of Fokker in electrodynamics. An action is first defined with the help of a Riesz function in terms of a parameter α to be determined by the method of analytical continuation. It is then shown that by expressing the mesic charge-current and dipole densities with the help of a Riesz function which for $\alpha \to 2$ behaves like Dirac's δ-function, the adjunct fields, which are introduced on purely formal grounds, satisfy the fundamental equations of meson field in the usual field theory for $\alpha \to 2$. The variation of the action function for $\alpha \to 2$ finally gives the required equations of motion. In the second section the adjunct fields, which are singular on the world line of the particle, are evaluated by the Riesz method of analytical continuation for $\alpha \to 2$. The scattering of mesons by nucleons are calculated in the last section. A.

530.145

736. Theoretical analysis of pion-nucleon scattering. N. Fukuda, S. Goto, S. Okubo and K. Sawada. *Progr. theor. Phys.*, **12**, *No.* 1, 79–93 (*July*, 1954).

Theoretical phase shifts of pion-nucleon scattering are derived assuming the pseudo-scalar meson theory with pseudo-scalar coupling. In order to make a static approximation for such a relativistic coupling, the Tani–Foldy transformation is applied. Since there appears an isotopic-spin-dependent term which is negative and rather strong for the $T = 1/2$ state, theoretical interpretation of recent experiments on the S-wave scattering seems to be hopeful. As to the P-wave scattering, the Tamm–Dancoff approximation and renormalization technique are used. The anomalous magnetic moment of the nucleon is also calculated. The cut-off method is used throughout this work and the results are very sensitive to the cut-off momentum, but the essential features of the theory would be retained qualitatively and, at lower energies, somewhat quantitatively. D-phase shifts are calculated by the Born approximation, though it is possible that the radiative effects, which always tend to make the nucleon spread out, are very important in this case. A.

530.145

737. On the effective Hamiltonian for pseudoscalar meson with pseudoscalar coupling with nucleon. T. AKIBA AND K. SAWADA. *Progr. theor. Phys.*, **12**, *No.* 1, 94–8 (*July*, 1954).

The method of canonical transformation is applied to the pseudoscalar meson theory with pseudoscalar coupling. It is shown that the Tani–Foldy transformation is the most suitable. The resulting Hamiltonian was ordered assuming some cut-off for the virtual meson momentum, and performing mass renormalization. This Hamiltonian appears useful in accounting for the S-phase shifts for the nucleon π-meson scattering; the L-S coupling $(\tau \cdot \phi \times \pi)$ in the isotopic spin space, which is positive for the $T = 3/2$ state and negative for the $T = 1/2$ state, becomes twice as large as that obtained by the perturbation theory. A.

530.145

738. Pseudoscalar nuclear field and polarization. M. VERDE. Letter in *Nuovo Cimento*, **12**, *No.* 3, 452–4 (*Sept.*, 1954).

The assumption that the nuclear field in the shell model is pseudoscalar leads to appreciable azimuthal effects in scattering, both for high and low energies, in qualitative agreement with experiment.

P. T. MATTHEWS

530.145

739. Self-energy effects on meson-nucleon scattering according to the Tamm–Dancoff method. W. M. VISSCHER. *Phys. Rev.*, **96**, *No.* 3, 788–93 (*Nov.* 1, 1954).

The lowest order Tamm–Dancoff equations for the meson-nucleon system are derived by the method of Cini, using the wave-functions defined by Dyson. The contributions of the meson and nucleon self-energies to the kernel of the momentum-space integral equation are renormalized. Their effects are absorbed into the coupling G^2, making it momentum and energy dependent. The effective coupling turns out to exhibit an anomalous behaviour, having a pole for a spacelike momentum, to which it is difficult to attach a sensible physical interpretation. A.

530.145

740. Mesonic corrections to the quadrupole moment of the deuteron. A. M. SESSLER. *Phys. Rev.*, **96**, *No.* 3, 793–6 (*Nov.* 1, 1954).

Mesonic corrections to the quadrupole moment of the deuteron are calculated by means of the method of Tamm and Dancoff. Only the two-nucleon and two-nucleon–one-meson amplitudes are included. The first is associated with a phenomenological wave-function for the deuteron, the second yielding a correction to the quadrupole moment. A correction exists even in neutral scalar theory, and for pseudoscalar (pseudoscalar) symmetric theory the result in adiabatic approximation to second order is $\Delta Q = 3 \cdot 1\%$ or $\Delta Q = -0 \cdot 7\%$, depending on choice of wave-functions (assuming $g^2/4\pi = 10$). Contributions from multiple meson amplitudes are examined, and for a hard-core deuteron function they are shown to contribute only slightly. A.

530.145

741. Realistic theory of pseudoscalar mesons. B. JOUVET. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 18, 1121–3 (*Nov.* 3, 1954) In French.

It is shown that by postulating pseudoscalar coupling between nucleons and leptons the existence of pseudoscalar mesons is implied, whose mass and coupling strengths could be calculated from the properties of the fermions involved. G. FIELD

530.145

742. Limiting processes in the formal theory of scattering. F. COESTER, M. HAMERMESH AND K. TANAKA. *Phys. Rev.*, **96**, *No.* 4, 1142–3 (*Nov.* 15, 1954).

The equivalence of different formal limiting processes employed in the theory of scattering is discussed by comparing the integral equations which hold for finite values of the parameter. A.

530.145

743. Solution of many-body scattering problems by Fredholm's equation. P. SWAN. *Phys. Rev.*, **96**, *No.* 4, 1144 (*Nov.* 15, 1954).

A reduction is made of the second-order linear integro-differential equation describing many-body elastic collisions to a Fredholm equation, for which an analytic solution can be constructed. The Fredholm equation is easier to solve numerically, an example being solved by iteration as an illustration of its use. A.

530.145 : 535.43

744. Scattering of light of very low frequency by systems of spin ½. F. E. LOW. *Phys. Rev.*, **96**, *No.* 5, 1428–32 (*Dec.* 1, 1954).

It is shown that the first two terms in the expansion of the scattering amplitude of light by a system of spin ½ in powers of the frequency can be simply expressed in terms of the macroscopic properties of the system. The first term is the well-known Thomson amplitude, and depends only on the total charge and mass. The second term is found to depend only on the charge, mass and magnetic moment of the system. A.

530.145 : 535.43

745. Scattering of low-energy photons by particles of spin ½. M. GELL-MANN AND M. L. GOLDBERGER. *Phys. Rev.*, **96**, *No.* 5, 1433–8 (*Dec.* 1, 1954).

The first two terms in a frequency expansion of the photon scattering amplitude are considered in the case where the scatterer is a particle of spin ½. It is shown that an exact calculation in quantum field theory gives results identical with those obtained by classical methods or else by use of the Dirac equation with an anomalous Pauli moment. The results depend only on the charge, mass and magnetic moment of the scatterer. In the case of the photon, the second term, arising from scattering by the magnetic moment, appears to be negligible in comparison with effects due to Thomson and Rayleigh scattering. A.

530.145

746. On the theory of collision of particles with a given angular momentum. V. T. KHOZYAINOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9) 275–82 (1954) In Russian.

A relativistic wave equation for the system of two fermions which possesses a definite angular momentum

is obtained with the use of vector spherical harmonics. Such a state is then represented as a superposition of plane waves, so that recent methods of calculation in momentum space can be applied to this system.

G. E. BROWN

530.145

747. Super-stationary variational method. T. KIKUTA. *Progr. theor. Phys.*, **12**, *No.* 1, 10–16 (*July*, 1954).

The stationary character in the usual variational method is extended by using a trial function with stationary character. A successive method for the improvement of the stationary character is also indicated. This method has been applied both to bound state problems and to continuous spectra (scattering problems). A.

530.145

748. Note to the solution of the Schrödinger equation for finite systems. T. TIETZ. Letter in *Nuovo Cimento*, **12**, *No.* 3, 449–51 (*Sept.*, 1954).

The number of eigenvalues is determined. Hypergeometric functions are involved. The note is preliminary and follows on the paper by Dingle [Abstr. 3886 (1953)]. L. S. GODDARD

530.145

749. A non-linear generalization of the Schrödinger and Dirac equations. II. M. SCHÖNBERG. *Nuovo Cimento*, **12**, *No.* 5, 649–67 (*Nov.*, 1954).

The method of generalization applied in Pt I [Abstr. 7125 (1954)] to the Schrödinger and Dirac wave-equations and to the classical Hamilton–Jacobi equation is extended to all the theories derived from variational principles admitting the gauge invariance of the first kind. By a slight change of the ordinary definition of the gauge transformations of the first kind, the Hamilton–Jacobi theory and the dynamics of the inviscid barotropic fluids are also included. In all cases, the method of generalization corresponds to the passage from the irrotational to the vortex motions of the inviscid fluids, although the part of the vorticity be taken over by other quantities. It is shown that theorems analogous to those of Helmholtz, Kelvin and Cartan and the Cauchy formula of the theory of the vortex motions of an inviscid barotropic fluid can be extended to the generalization of the gauge invariant field formalism, the vorticity being replaced by a non-integrability vector appearing in the formalism. The generalization method may be regarded as consisting in the replacement of quantities similar to the phases of the wave-functions by non-integrable quantities. A.

530.145

750. Properties of Bethe–Salpeter wave functions. G. C. WICK. *Phys. Rev.*, **96**, *No.* 4, 1124–34 (*Nov.* 15, 1954).

A boundary condition at $t = \pm\infty$ (t being the "relative" time variable) is obtained for the four-dimensional wave-function of a two-body system in a bound state. It is shown that this condition implies that the wave-function can be continued analytically to complex values of the "relative time" variable; similarly the wave-function in momentum space can be continued analytically to complex values of the "relative energy" variable p_0. In particular one is allowed to consider the wave-function for purely imaginary values of t, or respectively, p_0, i.e. for real values of $x_4 = ict$ and $p_4 = ip_0$. A wave equation satisfied by this function is obtained by rotation of the integration path in the complex plane of the variable p_0, and it is further shown that the formulation of the eigenvalue problem in terms of this equation presents several advantages in that many of the ordinary mathematical methods become available. In an especially simple case ("ladder approximation" equation for two spinless particles bound by a scalar field of zero rest mass) an integral representation method is presented which allows one to reduce the problem exactly (and for arbitrary values of the total energy of the bound state) to an eigenvalue problem of the Sturm–Liouville type. A complete set of solutions for this problem is obtained in the subsequent paper by Cutkosky. A.

530.145

751. Solutions of a Bethe–Salpeter equation. R. E. CUTKOSKY. *Phys. Rev.*, **96**, *No.* 4, 1135–41 (*Nov.* 15, 1954).

The discussion in the preceding abstract of a simplified Bethe–Salpeter equation is continued. Two methods are used to find a complete set of solutions, an integral transform method and an adaptation of Fock's treatment of the hydrogen atom. The degeneracy is found to be the same as that of the non-relativistic hydrogen. In addition to the solutions which have the expected nonrelativistic limit, a large number of anomalous solutions are obtained. The behaviour in the limit in which the mass of one particle becomes infinite is considered, and it is found that in this limit the ladder approximation gives an equation which does not correspond to the motion of a particle in the field of a fixed centre of force. A.

530.145

752. Note on perturbation theory. S. T. EPSTEIN. *Amer. J. Phys.*, **22**, *No.* 9, 613–14 (*Dec.*, 1954).

Perturbation theory is derived in such a way that the wave-function renormalization terms appear automatically. The derivation is based on the Feynman theorem for the rate of change of an eigenvalue with respect to a parameter, and a corresponding theorem for the rate of change of an eigenfunction. A.

530.145 : 530.162

753. Method of transition probabilities in quantum mechanics and quantum statistics. P. T. LANDSBERG. *Phys. Rev.*, **96**, *No.* 5, 1420–7 (*Dec.* 1, 1954).

The concepts microscopic reversibility, detailed balancing, equal probabilities, equilibrium, H theorem are often used in (coarse grained) quantum statistics. It is pointed out that each has a (fine grained) quantum-mechanical counterpart. These concepts are formulated, and their interrelations discussed, at an abstract mathematical level. The results are then interpreted by taking first the fine-grained and then the coarse-grained point of view. A type of transition matrix arises which does not seem to have been investigated so far, and some of its properties are discussed. A.

530.162

754. On a new method in the theory of interacting Fermi-particles. D. N. ZUBAREV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 5(11) 548–59 (1953) In Russian.

A "mixed" representation is developed, in which the wave-function of a system is written explicitly and from the start as a function of the position (and spin) co-ordinates r_1, r_2 . . . r_N of the N particles and a number of "redundant" collective co-ordinates ρ_{k_1}, ρ_{k_2} . . , where ρ_{k_j} is the k Fourier component of the density operator $\rho(r) = \sum_N \delta(r - r_j)$. The resulting Schrödinger equation, after a series of transformations and 2nd quantization, can be written in such a form that the Hamiltonian is $H = H_0 + H_1$, where H_0 is the sum of free oscillations of fermions and bosons (the latter corresponding to "phonons" or density waves) and H_1 represents (1) the interactions between the bosons, (2) fermion-boson interaction, (3) a screened fermion interaction. The characteristic frequencies of the fermion and boson branches of the spectrum associated with H_0 are easily written down. In the limit of weak interactions the latter corresponds to the sound velocity in the Fermi gas, and in the case of Coulomb interactions to the Langmuir plasma frequency. The conditions for $H_1 \ll H_0$ are derived and discussed in relation to the Debye screening length [see Abstr. 5379 (1951), 2688 (1952) and 3324 (1951)]. W. J. SWIATECKI

530.162

755. On the spectrum of excited systems of many particles. V. P. SILIN. *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9) 269–74 (1954) In Russian.

The influence of the correlation of particles arising from their identity (from symmetrization or anti-symmetrization) on the statistical distribution function for many particles is investigated in first order in its effects. The spectrum differs only slightly from that given by the self-consistent field approach. It is shown that this latter approach is inapplicable in an electron-ion plasma if the interaction energy between particles is comparable to their kinetic energy. G. E. BROWN

530.162

756. A simple derivation of a general equilibrium equation, with two astrophysical applications. P. O. FRÖMAN. *Ark. Fys.*, **8**, *Paper* 16, 173–5 (1954).

If the statistical mechanical formula, which has been derived by O. Klein, is combined with the well-known thermodynamical equilibrium condition containing the chemical potentials μ_r, one immediately obtains the general equilibrium equation, which contains as special cases Saha's formula and another well-known formula of great astrophysical importance. A.

530.162

757. Derivation of the energy spectrum from the specific heat for a Bose assembly. I. M. LIFSHITS. *Zh. éksper. teor. Fiz.*, **26**, *No.* 5, 551–6 (1954) In Russian.

The distribution in energy of single-particle states is derived by a method similar to the Laplace inversion of classical partition functions. The Fourier transform of the required distribution function is obtained in terms of the Fourier transform of an experimental temperature function. In performing the final Fourier inversion, a cut-off procedure has to be applied, in order to enforce convergence; the resulting spectral density represents accordingly an average over a finite band of energy levels. The author's method applies only to assemblies of quasi-particles (phonons, rotons) the number of which is indeterminate.

R. EISENSCHITZ

530.162

758. Condensation of an ideal Bose gas in a gravitational field. B. T. GEĬLIKMAN. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 1(7) 118–20 (1954) In Russian.

The Schrödinger equation for a particle in a box (height L) and in a gravitational field, is solved rigorously in terms of Bessel functions. The resulting energy spectrum is used for finding the thermodynamic quantities of the corresponding Bose–Einstein assembly. It is found that there is condensation similar to that of a gas without a field of force; in particular, the pressure becomes independent of the volume below the critical temperature T_0. The specific heat curve, instead of having a kink, decreases discontinuously (2nd-order transition) by $2{\cdot}612\ (9/8)(mgL/kT_0)^{\frac{1}{2}}k$ per molecule. R. EISENSCHITZ

530:162

759. A method in quantum statistical mechanics. III. Virial expansion for the quantum gas. H. ICHIMURA. *Progr. theor. Phys.*, **11**, *No.* 6, 519–27 (*June*, 1954).

For Pt II, see Abstr. 10820 (1954). As an application of the general expansion formula of the grand partition function for the system of interacting particles, the virial expansion formula for quantum gases is derived under the assumption that the degeneracy parameter λ is very small. A formula for the second virial coefficient is obtained which is effective at extremely low temperatures. A.

530.162 : 536.7

760. Solution of the temperature-perturbed Thomas–Fermi equation. J. J. GILVARRY. *Phys. Rev.*, **96**, *No.* 4, 944–8 (*Nov.* 15, 1954).

An analytic solution of the temperature-perturbed Thomas–Fermi equation of nth order is given in terms of quadratures on the unperturbed solution corresponding to zero temperature. The boundary and initial parameters corresponding to a solution, necessary for the thermodynamics, are given as explicit integrals in terms of the unperturbed solution, on the basis of a boundary condition for fixed atomic volume. Thus, every thermodynamic function at low temperature can be written as an asymptotic series, either in the even or the odd powers of the temperature, with coefficients which can be expressed in terms of quadratures on the zero-temperature solution. In particular, the coefficients of the asymptotic series corresponding to the basic thermodynamic functions (pressure, energy, entropy, enthalpy, Helmholtz and Gibbs functions) can be expressed algebraically in terms of such quadratures. These results extend and generalize a similar result obtained by M. G. Mayer, restricted to the first-order temperature-perturbed case. The theory is applied in detail to the first-order case. From six neutral-atom zero-temperature solutions due to Feynman, Metropolis and Teller, accurate values of the corresponding boundary and initial parameters of the first-order temperature-perturbed equation are

obtained for the case of fixed atomic volume under the temperature perturbation. A.

530.162 : 537.12

761. On the theory of the energy spectra of quantum systems of interacting particles. V. L. BONCH-BRUEVICH. *Zh. éksper. teor. Fiz.*, **25**, *No.* 4(10) 417–28 (1953) In Russian.

A method of studying weakly excited states of a system of many particles which is applicable to both the Bose and Fermi branches of the spectrum, and also the formulation of conditions for the existence in a given system of the one or the other type of excitation. Only particles with antisymmetrical statistics (electrons) are considered. The ground state of the system is described by a Ψ_0 which, according to the method of second quantization, is a function of the occupation numbers of certain one-particle states n (=0 or 1). Excited states are written as the result of an operation on Ψ_0 with an operator consisting of a sum of products of creation and annihilation operators with weights given by a certain function f. Using the stationary property of the total energy an eigen-equation is derived for f (which plays the rôle of wave-function for a system of "elementary excitations" of Bose or Fermi type). The equation for f is often rather complicated. Allied papers are Abstr. 3324, 5379 (1951), 2688 (1952). W. J. SWIATECKI

530.162 : 537.12

762. The electric conduction of metals, taking account of the electron interaction. Case of a Fermi spectrum. S. V. VONSOVSKIĬ AND B. V. PADUCHEV. Letter in *Zh. éksper. teor. Fiz.*, **25**, *No.* 4(10) 510–12 (1953) In Russian.

The treatment of Abstr. 6210 (1951) and preceding abstract, based on the formalism of second quantization, when applied to the case of a Fermi spectrum of the "elementary excitations," leads to a T^5 dependence of the specific resistance of metals at low temperatures. (Compare T or T^2 for bosons.)

W. J. SWIATECKI

530.162 : 539.153

763. The uncertainty principle and the Bohr theory of the hydrogen atom. Y. P. VARSHNI. Letter in *Amer. J. Phys.*, **22**, *No.* 8, 568 (*Nov.*, 1954).

530.162 : 536.7

764. Quantum statistics of irreversible processes. N. G. VAN KAMPEN. *Physica*, **20**, *No.* 9, 603–22 (*Sept.*, 1954).

The concept of time-proportional transition probabilities is essential for statistical mechanics of non-equilibrium states. In quantum mechanical treatments it is usually justified by an appeal to Dirac's perturbation theory. This justification is here criticized, and a new approach is developed. The main problem is to understand why it should be permissible to discard the cross-products of two different probability amplitudes which appear on calculating probabilities ("interference of probabilities"). For this purpose phase cells are introduced, consisting of a large number of different quantum states which are indistinguishable for a macroscopic observer. In the expression for the expectation value of a macroscopic variable the cross-products between all probability amplitudes belonging to a cell occur. It is argued that, owing to their large number and their randomly varying complex phase angles, these terms tend to cancel each other, so that only the squared terms survive. Hence, the macroscopic aspect of the state is determined if only the total probability in each cell is known. Moreover, the values of these probabilities at any time $t > 0$ can be expressed in those at $t = 0$. Thus the macroscopic behaviour in time can be described by a first-order differential equation of the customary type. (Irreversibility here enters through the assumption of randomly varying phase angles.) The coefficients in the equation may be interpreted as transition probabilities; they satisfy a symmetry relation, which is sometimes called microscopic reversibility. After a transformation to observable quantities the differential equation takes the form of the usual "phenomenological equations," and the symmetry gives rise to the Onsager relations. A.

GENERAL MECHANICS
MECHANICS OF SOLIDS 531

531.11

765. Finding the external force. T. D. PHILLIPS. *Amer. J. Phys.*, **22**, *No.* 9, 583–5 (*Dec.*, 1954).

Ambiguity in the statement of Newton's first law of motion occurs in most introductory physics texts. This is due to vagueness or inconsistency in the use of the word *body*. To make the statement of the law plain in meaning three revised wordings are available. In the opinion of the writer the best solution is to substitute the phrase, the *centre of mass of any body* in the place of the common phrase *every body*. A.

531.111.4

766. A way of representing the motion of a classical system as being along a geodesic in space-time. H. L. ARMSTRONG. *Amer. J. Phys.*, **22**, *No.* 9, 615–17 (*Dec.*, 1954).

Ordinarily, the Jacobi formulation of classical mechanics describes a system by giving the path of a "system point" in "configuration space," the path being a geodesic if a metric is suitably defined. Nothing is said, however, about the motion in time. It is suggested here that, by adding a degree of freedom in uniform motion to serve as a clock, and identifying the time with the co-ordinate of that degree of freedom, the configuration space can be extended to a space-time, in which the motion is completely described, both in space and in time, as being along a geodesic. Also, by this representation, the idea of "absolute time" is made unnecessary. A representation such as this is, of course, normal in relativistic theory, but its use here in non-relativistic mechanics is believed to have some novelty. A.

531.383 : 539.622

767. The tippe top. C. M. BRAAMS. Letter in *Amer. J. Phys.*, **22**, *No.* 8, 568 (*Nov.*, 1954).

Comments, from a practical standpoint, on the different ways in which the motion of the top can be described and adds some remarks on the sliding of the point of contact. [See also Abstr. 3151 (1954).]

S. WEINTROUB

MECHANICAL MEASUREMENTS 531.7

531.712 : 771.372

768. Range finder without moving mechanical parts. E. W. H. SELWYN. Note in *J. sci. Instrum.*, **31**, *No.* 12, 476 (*Dec.*, 1954).

A simple system is suggested as a rangefinder for a camera. The movement of one element of the rangefinder is equal to the movement of the camera lens to attain exact focus for a given object distance. No parallax correction is required in one arrangement.

R. W. FISH

531.714

769. Sensitivity of a vibrating reed null indicator. I. J. SOMERVAILLE. *J. sci. Instrum.*, **31**, *No.* 12, 439–40 (*Dec.*, 1954).

A simple vibrating reed null detector is described. The sensitivity of the instrument has been studied by two methods. In each case consecutive readings were obtained within $\pm 2\times10^{-6}$ in. A.

531.717.1 : 541.64

770. A modified apparatus for measuring the swelling of polymer films in solvents. N. STOLOW. *J. sci. Instrum.*, **31**, *No.* 11, 416–20 (*Nov.*, 1954).

An apparatus, incorporating the principle of the parallel plate viscometer, is described which enables the swelling of films to be accurately measured in organic solvents at various temperatures and under diverse flow conditions. Complete safety of operation is ensured by means of baffles arranged about the parallel plates. The theory is discussed and formulae are derived which accurately predict the sensitivity with both liquids and gases except when the flow is turbulent. The scale of the microscope focusing mechanism used is calibrated by means of a standard slip gauge employing a gas flow technique. A non-destructive method for the measurement of film thickness of gel-like films is described in which a flow of nitrogen locates the surface of each film at a constant distance away. The manner of swelling measurement is indicated and in addition the use of the apparatus for desorption measurements upon swollen films is discussed. A.

531.717.3 : 620.172.222 : 621.317.39

771. A simple circuit for use with condenser strain gauges. D. M. MAURICE. *J. sci. Instrum.*, **31**, *No.* 12, 442–4 (*Dec.*, 1954).

A one-valve circuit operating at 200 Mc/s is described which gives a stable output proportional to the strain and sufficient to drive directly a low-impedance recording milliammeter. It may be used with a wide range of recording capacitances down to 3 pF. The connecting cable to the recording condenser acts as a transmission line and may be long without affecting seriously the working of the circuit. A.

531.717.3 : 621.317.79

772. A direct reading instrument for the measurement of small displacements. W. D. CORNER AND G. H. HUNT. *J. sci. Instrum.*, **31**, *No.* 12, 445–7 (*Dec.*, 1954).

A differential condenser forms part of an a.c. bridge network. Displacement of the central plate causes a proportional off-balance voltage. Small displacements can be measured to an accuracy of 10^{-7} cm. A.

531.751.1

773. Further tests on the stability of analytical weights in chemical laboratories. P. H. BIGG AND F. H. BURCH. *Brit. J. appl. Phys.*, **5**, *No.* 11, 382–6 (*Nov.*, 1954).

The stability, in the corrosive atmospheres of chemical laboratories, of brass weights coated electrolytically with nominal thicknesses of 13 μ and 25 μ of tin-nickel alloy (65% Sn, 35% Ni) has been compared with that of weights previously tested [Abstr. 6052 (1951)] under similar conditions. As regards appearance after exposure, the 25 μ coating was the best, and was comparable with weights of highly-polished stainless steel save in the severest conditions. All the alloy-coated weights showed about the same stability of mass as good quality commercially produced weights of austenitic stainless steel (25% Cr, 20% Ni) and rhodium-plated brass weights. Tin-nickel alloy plating does not possess any undesirable magnetic properties. In highly corrosive atmospheres, non-magnetic nickel-chromium (80% Ni, 20% Cr) is a little less resistant than the materials already mentioned. Of the small sheet metal weights of various materials tested, those of austenitic stainless steel were definitely the best. They were followed, in order of merit, by zirconium, tantalum and aluminium, and finally, titanium. A.

531.787

774. A sensitive miniature pressure cell. S. C. REDSHAW. *J. sci. Instrum.*, **31**, *No.* 12, 467–9 (*Dec.*, 1954).

The design, construction and calibration of a pressure cell which was developed primarily for the measurement of earth pressures is described. The cell consists of two metal disks, having an external diameter of 1 in., between which a plastic ring is cemented; the thickness of the unit is $\frac{1}{4}$ in. A special rosette type of foil resistance strain gauge is attached to the inner surface of each disk and the strain gauge assembly connected up to give a four active arm bridge with automatic temperature compensation. The cell exhibits a linear pressure-signal response from 0–100 lb/in.^{2} and it may be used for either dynamic or static recording of pressure. The output from the bridge is 0·025 mV per (lb/in.^{2}) per V, which could be increased if desired. Conventional potentiometric methods of recording the signal from the unit may be used. A.

MECHANICS OF FLUIDS 532

532.13 : 541.6

775. Viscosity and the structure of molten silicates. J. O'M. BOCKRIS AND D. C. LOWE. *Proc. Roy. Soc. A*, **226**, 423–35 (*Dec.* 7, 1954).

A magnetically controlled null-point modification of the rotating crucible viscometer has been devised which enables measurements of the viscosity of liquids to be made at maximum temperatures of

1850°c. The instrument has been applied to measure the viscosity of the system $CaO–SiO_2$ over the composition range 30 to 58 mole % CaO. The flow is Newtonian. The viscosity isotherms are smooth functions of composition and do not exhibit the inflection found in previous work carried out in (attackable) graphite crucibles. Up to 1700°c the energy of activation is constant for all systems. For compositions containing more than 38·8 mole % CaO, the energy of activation falls at temperatures 1700°c. The energy of activation is small compared with that for flow in liquid silica. Over the composition range studied it falls little (45 to 35 kcal $mole^{-1}$) with increase of CaO content. The energy of activation observed is inconsistent in magnitude and variation with composition with the current theory of the structure of liquid silicates and glasses due to Endell and Hellbrügge. In liquid SiO_2 and systems containing less than about 12 mole % metal oxide the flow unit is SiO_2. At about this composition a fundamental change occurs in the structure of the melt. For systems with a metal oxide content of more than about 12 mole % the flow unit is a discrete silicate anion, the size of which increases regularly with increasing concentration of SiO_2. The simplest discrete silicate anions compatible with valency, stereochemical and electro-neutrality considerations are deduced for various compositions of the liquid. The structure thus suggested is consistent with observations on the viscosity of silica and of the system $Na_2O–SiO_2$; and with results on the temperature of maximum density in silica, X-ray diffraction in glasses, the solubility of CaF_2 in silicates, and the partial molar volume results for simple alkali metal glasses. A.

532.57

776. A portable electric velometer for low velocity liquids. A. D. Misener. *Canad. J. Technol.*, **32**, *No.* 6, 242–9 (*Nov.*, 1954).

An electric instrument is described which is capable of measuring the flow velocities of liquids up to four miles per hour with an accuracy of better than 0·1 m.p.h. The absolute accuracy improves at lower velocities. The instrument described is self-contained and portable, suitable for study of stream velocities, erosion currents, ground runoff, etc. It may be readily adapted to become a recording velometer for any liquid, either in pipes or open channels. Its operation is not affected by sediments and suspended solids carried by the liquids. A.

CAPILLARITY 532.6

532.61 : 530.162

777. Statistical mechanics of surface tension of curved interface. I. T. Segawa and E. Teramoto. *Progr. theor. Phys.*, **11**, *No.* 6, 528–36 (*June*, 1954).

From the microscopic point of view, surface tension is defined in two different ways: the statistical-thermodynamic and, so to speak, the kinetic. These two definitions are examined with regard to a cylindrical interface between liquid and vapour, and it is shown that under certain conditions these two definitions become equivalent to each other and also to the usual thermodynamic definition. The methods used are those due to Harasima, MacLellan and Kirkwood and Buff. The possibility of extending these methods to a spherical interface are briefly mentioned, leaving detailed calculations to be covered by future papers. A.

532.612.4

778. A table for the calculation of surface tension from measurements of sessile drops. N. R. Tawde and K. G. Parvatikar. *Indian J. Phys.*, **28**, *No.* 7, 345–8 (*July*, 1954).

The present paper is an extension of the work of Tawde and Parvatikar on sessile drops. A table is prepared of the values of a^2/r^2 against h/r in the range from 0·5100 to 0·5708 at interval of 0·0002. A.

532.62

779. Self-potentials in very thin films. R. M. Barrer. *Trans Faraday Soc.*, **50**, *Pt* 10, 1074–7 (*Oct.*, 1954).

In extremely thin liquid-like films, self-potentials quickly approach those characteristic of the same liquid in bulk. This is true of films three or more molecules thick. Properties such as surface tension which are related to intermolecular forces thus may also quickly approach their values for bulk liquid. The sorbate-sorbate potential can be related to the heats liberated when gas molecules enter close-packed monolayers. These heats may differ according as the film behaves as a localized or a non-localized monolayer. This may provide a means of determining the character of the monolayer at or near saturation. A.

MOLECULAR THEORY OF LIQUIDS 532.7

532.7 : 533.7 : 539.13

780. On a kinetic theory of systems of interacting particles. A. E. Glauberman. *Zh. éksper. teor. Fiz.*, **25**, *No.* 5(11) 560–70 (1953) In Russian.

The derivation of the kinetic distribution functions for a system consisting of interacting particles of different kinds in the presence of external forces depending on the positions and velocities. In the case of conservative forces the equilibrium distribution functions are deduced. Using the method of N. N. Bogolyubov (*Problems of the dynamical theory in statistical physics*, monograph, OGIZ, 1946) the distribution functions for a system of charged particles (ions) of different kinds are studied. [See also H. Born and H. Green, *A general kinetic theory of liquids*, Cambridge, 1949, and A. E. Glauberman, Abstr. 8613 (1953).] W. J. Swiatecki

532.7

781. On the free volume theory of liquid. K. Arakawa. Note in *J. Phys. Soc. Japan*, **9**, *No.* 4, 647–8 (*July–Aug.*, 1954).

An approximation is proposed for the generalized free volume $j(\omega)$ assuming $z\omega_1$ cells are vacant and $z(1-\omega i)$ are occupied around ith molecule and that a cell can only accommodate one molecule. Slightly better agreement appears to have been obtained than with previous theories but further improvement will

require enlargement of cell capacity and consideration of interaction of molecules between different cells.

T. C. TOYE

532.7

782. Cell-cluster theory for the liquid state. I. J. DE BOER. *Physica*, **20**, *No.* 9, 655–64 (*Sept.*, 1954).

A generalization is given of the cell method for the liquid state, by taking into account in a systematic way the collective motion of more than one molecule in cell-clusters of more than one cell. A rigorous expression is derived for the partition function in terms of cell-cluster integrals over clusters of two, three, etc., cells, but for the evaluation of the corresponding complicated combinatorial problem approximative methods have to be used. The applications will be given in subsequent publications. A.

532.72

783. Temperature dependence of diffusion in aqueous solutions. L. G. LONGSWORTH. *J. phys. Chem.*, **58**, *No.* 9, 770–3 (*Sept.*, 1954).

The diffusion coefficients, in dilute aqueous solution, of some representative materials whose molecular weights range from 19 to 68 000 have been determined at several temperatures. The results indicate that the temperature coefficient for diffusion increases only slightly with increasing particle size and is less than that predicted by the Stokes–Einstein relation (assuming the diffusion radius to be independent of the temperature) only for solute molecules so small that the solvent, water, cannot be considered a continuum. A.

532.72

784. Diffusion coefficients for the system biphenyl in benzene. C. L. SANDQUIST AND P. A. LYONS. *J. Amer. Chem. Soc.*, **76**, *No.* 18, 4641–5 (*Sept.* 20, 1954).

The diffusion coefficients, densities, viscosities and molar refractive increments for solutions of biphenyl in benzene have been determined at 25 and 35° in the concentration region 0–3 molar. Attention has been called to the significance of the overlapping of the plots of $D\eta/T$ against $\bar{c}$ at the two temperatures. A simple and useful deviation function has been proposed for the description of this type system. The activation energies for the viscous and diffusion processes have been compared. The suggestion has been made that the data, in particular at 25°, constitute reliable standards for calibration purposes. A.

532.72

785. The diffusion coefficient of sodium chloride. E. A. GUGGENHEIM. *Trans Faraday Soc.*, **50**, *Pt* 10, 1048–51 (*Oct.*, 1954).

The precise measurements made by Harned and Hildreth of the diffusion of sodium chloride in aqueous solution at 25°c have been analysed as thoroughly as possible. It is found that the kinematic diffusion coefficient, in contrast to the Fick's law coefficient, is almost independent of concentration. The trend in its value scarcely exceeds the random experimental errors, but is consistent with the predictions of Onsager's theory. A.

532.72 : 541.135

786. Effect of ions on the self-diffusion and structure of water in aqueous electrolytic solutions. J. H. WANG. *J. phys. Chem.*, **58**, *No.* 9, 686–92 (*Sept.*, 1954).

Liquid water has a semi-crystalline structure. Dissolved ions cause distortion or partial destruction of the structure of water. Such a distortion effect can be used to interpret (1) the temperature coefficients of the limiting equivalent conductances of spherical ions in water, and (2) the observed concentration dependence of the tracer-diffusion coefficient of ions with salt concentration in moderately concentrated salt solutions. Direct evidence of such a distortion effect has been obtained in the present work where the self-diffusion coefficient of water in a series of electrolytic solutions has been measured as a function of the concentration of the electrolyte. In some cases the measured self-diffusion coefficient of water in salt solution is much higher than that in pure water, indicating that in these solutions the structure of water is distorted or partially destroyed to a considerable extent. The effect of such a distorted water structure on the equilibrium properties of the ions is discussed. The relationship between the measured viscosity of the solution and the self-diffusion coefficients of the constituent molecular species is also examined. A.

532.73

787. Partial molal volumes of hydrocarbons in water solution. W. L. MASTERTON. *J. chem. Phys.*, **22**, *No.* 11, 1830–3 (*Nov.*, 1954).

The partial molal volumes of benzene, methane, ethane and propane in water solution have been determined at temperatures ranging from 10 to 40°c. All the volumes measured were less than those of the same hydrocarbons in non-polar solvents. This decrease in volume is explained in terms of the abnormally high internal pressure of water, which decreases the free volume available to the hydrocarbon molecules. The temperature dependence of the partial molal volumes of the aliphatic hydrocarbons differs sharply from that of benzene. It is suggested that this is caused by a difference in solution structure in the two cases. A.

MECHANICS OF GASES 533

533.5

788. Ion pump. P. F. VÁRADI. *Acta tech. Hungar.*, **9**, *No.* 3–4, 343–54 (1954).

Obtainable values of the ultimate vacuum and the pumping speed as functions of the tube geometry and the anode current were examined by means of a simple model. Experiments were conducted in order to demonstrate the exhausting and compressing effects as well as to distinguish adsorption from pumping. However, a quantitative evaluation of the phenomenon is only possible at higher current densities. A.

533.5

789. An instrument for leak detection and pressure measurement in high vacuum systems. E. G. LEGER. *Canad. J. Technol.*, **32**, *No.* 6, 199–205 (*Nov.*, 1954).

An instrument is described for measuring gas pressure in the range 10^{-1} to 10^{-7} mm of mercury.

At the higher pressures vacuum thermocouples are used and at the lower pressures ionization gauges. Leaks are detected by spraying oxygen on the outside of the vacuum system and noting the decrease in electrons from a tungsten filament emitter in an ionization gauge when it is operated as a saturated diode. Leaks are traced either by observing a meter or by means of the change in frequency of an audio-oscillator. To avoid damage an automatic cut-off is used to turn off the gauges and diffusion pumps when the pressure reaches a predetermined value. A.

533.5 : 531.788

790. Compensated ionization gauge for vacuum measurements of high relative accuracy. J. W. HIBY AND M. PAHL. Note in *Z. Naturforsch.*, **9a**, *No.* 10, 906–7 (*Oct.*, 1954) In German.

The advantages of a bridge circuit which eliminates variations in the emission current are described.

G. WITTENBERG

533.5 : 531.788

791. A thermionic ionization gauge of high sensitivity employing a magnetic field. G. K. T. CONN AND H. N. DAGLISH. *J. sci. Instrum.*, **31**, *No.* 11, 412–16 (*Nov.*, 1954).

An arrangement consisting of a cylindrical anode, an axial thermionic filament and an axial magnetic field provides a high electron density if the magnetic field is sufficient to prevent most of the electrons reaching the anode. End plates, perpendicular to the axis and maintained at a negative potential relative to the filament, serve the double purpose of preventing the escape of electrons and collecting ions if gas is present. Such an arrangement forms a simple vacuum gauge the sensitivity of which may be at least 100 times that of the conventional thermionic gauge; for normal use robust pivoted meters may be used in place of galvanometers or d.c. amplifiers. The ion current is linear with pressure below 10^{-4} mm of mercury. Characteristic curves are presented and the action of the instrument is interpreted in terms of these. A.

533.5 : 531.788

792. A recording vacuum gauge. D. T. HURD AND M. L. CORRIN. *Rev. sci. Instrum.*, **25**, *No.* 11, 1126–8 (*Nov.*, 1954).

The Langmuir viscosity vacuum gauge has been modified to provide electrical recording of low-pressure data. A particular advantage of this type of gauge is that, once calibrated, it may be used with any gas, including reactive or unstable compounds, or with gases having low condensation pressures. The gauge utilizes the changing capacitance between a stationary electrode and an oscillating fibre the rate of damping of which is a function of the composition and pressure of the ambient gas, to modulate the frequency of an oscillator. The output from the oscillator is demodulated in a discriminator circuit, amplified and recorded. The pressure of the gas is then determined from the recorder trace. Alternatively, the signal may be used to actuate relays or servomechanisms. The fibre is set into oscillation by means of an electromagnet, so the entire operation of the device may be made automatic if desired. A.

533.6 : 534.23

793. Pressure effects of relaxation and bulk viscosity in gas motion. L. J. F. BROER. *Appl. sci. Res. A*, **5**, *No.* 1, 55–64 (1954).

A comparative study is made of the pressure effect of relaxation and bulk viscosity in stationary flow. It is shown that both stagnation pressure defects (Kantrowitz effect) and pressure distribution in small nozzles in principle constitute methods for distinguishing between the two theories. A discussion of the experimental data on carbon dioxide shows that in this case only the relaxation interpretation is possible. A.

533.6.011.311

794. Boundary layer growth in three dimensions. L. C. SQUIRE. *Phil. Mag.*, **45**, 1272–83 (*Dec.*, 1954).

The analysis of Goldstein and Rosenhead (1936) for the boundary layer growth on an impulsively started body has been extended to three-dimensional bodies. The results are used to test various criteria of three-dimensional separation. A.

533.6.08

795. A simple vane anemometer giving continuous and direct indication of wind velocity. A. E. HAWKINS. *J. sci. Instrum.*, **31**, *No.* 11, 404–5 (*Nov.*, 1954).

By using the shaft of a vane anemometer as a switch to charge and discharge a condenser, continuous indication of wind velocity is presented as a deflection of a microammeter. The instrument is robust, portable and sensitive to small variations in wind velocity. A.

MOLECULAR THEORY OF GASES 533.7

533.7 : 536.71

796. The second virial coefficients of mixtures of polar and non-polar vapours. J. D. LAMBERT, S. J. MURPHY AND A. P. SANDAY. *Proc. Roy. Soc. A*, **226**, 394–9 (*Nov.* 23, 1954).

The second virial coefficients of binary mixtures of *cyclo*hexane with diethylamine, acetonitrile and acetone have been measured at 53 and 76°C. The experimental results are in fair quantitative agreement with a theoretical treatment based on the hypothesis that the polar vapours are partly associated. A.

533.7 : 539.13

The theory of collisions between two diatomic molecules. *See Abstr.* 1080

VIBRATIONS . ACOUSTICS 534

534.133

797. Study of the maximum speed attained at the breaking point by a quartz vibrator whose sinusoidal oscillation does not deform the moving surface. N. SÉGARD AND E. BESÈME. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 17, 1021–3 (*Oct.* 27, 1954) In French.

Enquires into the maximum velocity which can be obtained without fracture by the surface of a

quartz vibrator. It is shown that this is less than the minimum velocity required to show a Doppler effect from a single reflection. See also Abstr. 3407 (1951). W. BARDSLEY

534.151

798. On the mutual influence of spheres in vibrating air. W. STASZEWSKI. *Acta phys. Polon.*, **13**, *No.* 3, 209–24 (1954).

The force acting on small spheres in a Kundt tube placed at different distances from each other with their line of centres normal to the vibration vector has been investigated. When the spheres are close together this force is shown to be one of attraction or repulsion according to the size of the spheres as well as to the frequency and intensity of air vibrations. The contradiction of R. S. Cook's and E. N. da C. Andrade's results is thus explained, the conditions of their experiments differing considerably. A.

534.151

799. Vibrating plate method of producing powder ridges in a sound field. M. D. WALLER. *J. sci. Instrum.*, **31**, *No.* 11, 410–12 (*Nov.*, 1954).

A circular brass plate vibrating in the mode which includes one nodal circle, will, at suitable intensities, produce circular powder ridges on a horizontal surface situated a few millimetres below it. This rapid method of experiment makes it possible to study the numerous variables which affect the formation of powder ridges in an oscillating fluid. Size of particle is, for instance, of fundamental importance. Intensity effects are relatively small. A.

534.21

800. On the propagation of elastic waves in aeolotropic media. I. General principles. M. J. P. MUSGRAVE. *Proc. Roy. Soc. A*, **226**, 339–55 (*Nov.* 23, 1954).

Using the principle of least action the equations of motion and momentum conditions for elastic disturbances in any continuous medium are derived. Consideration of energy flux defines the form of the wave surface as the first negative pedal of the surface of phase velocities for elastic plane waves in the medium. A general method for obtaining the forms of these surfaces and an associated inverse surface is given and general conclusions about the propagation of disturbances are drawn. A.

534.21

801. On the propagation of elastic waves in aeolotropic media. II. Media of hexagonal symmetry. M. J. P. MUSGRAVE. *Proc. Roy. Soc. A*, **226**, 356–66 (*Nov.* 23, 1954).

The general analysis presented in Pt I is adapted to obtain the velocity, inverse and wave surfaces of a medium of hexagonal symmetry. Values derived from the elastic constants of (*a*) zinc, and (*b*) beryl are tabulated and graphs of sections of the surfaces have been drawn. The details of the propagation of elastic plane waves in a single crystal of either substance may be obtained from the data presented. A.

534.22 : 532.7

802. On the relation between sound velocity and intermolecular free length of liquids. Y. WADA. Note in *J. Phys. Soc. Japan*, **9**, *No.* 4, 641–2 (*July–Aug.*, 1954).

A simple theoretical foundation is given for Jacobson's proposed formula [see Abstr. 5614 (1952)]. T. C. TOYE

534.222.2

803. Structure of a steady-state plane detonation wave with finite reaction rate. J. G. KIRKWOOD AND W. W. WOOD. *J. chem. Phys.*, **22**, *No.* 11, 1915–19 (*Nov.*, 1954).

An analytical elaboration of von Neumann's model of the detonation wave is presented. A hydrodynamic argument for the well-known Chapman–Jouguet condition is advanced, and the sound speed to be used therein is identified as that obtained with frozen chemical equilibrium, in agreement with a recent result of Brinkley and Richardson. Possible situations in which the classical Chapman–Jouguet hypothesis might be incorrect are very briefly discussed. A.

534.222.2

804. Diameter effect in condensed explosives. The relation between velocity and radius of curvature of the detonation wave. W. W. WOOD AND J. G. KIRKWOOD. *J. chem. Phys.*, **22**, *No.* 11, 1920–4 (*Nov.*, 1954).

The limiting slope of the detonation velocity-wave front curvature locus for small velocity deficits is obtained under an assumption concerning the "reaction zone length" as related to the charge diameter and the radius of curvature of the wave front. The model is an extension to two dimensions of von Neumann's classical theory of the plane wave detonation. A.

534.222.2

805. The quasi-cylindrical shock tube. W. CHESTER. *Phil. Mag.*, **45**, 1293–301 (*Dec.*, 1954).

The disturbance produced behind a shock wave of arbitrary strength, travelling along a tube of varying cross-section, is investigated. The shape of the cross-section is arbitrary and the problem is linearized on the basis of small variations in area along the length of the tube. It is found that if the initial cross-sectional area is S, and there is a net change in area of amount $[\Delta S]$, then the consequent change in pressure behind the shock is $-K(p_1 - p_0)[\Delta S]/S$, where $(p_1 - p_0)$ is the initial pressure discontinuity across the shock. The parameter K decreases monotonically with the shock strength and $0{\cdot}5 \geqslant K > 0{\cdot}394$. More generally it is shown that the pressure is affected by two distinct perturbations superimposed on the initial flow, namely a permanent modification arising directly from the variations in cross-section, and a transient disturbance reflected from the shock and propagated with sonic velocity relative to the main flow. Expressions for both these contributions are obtained. A.

534.222.2

806. Shock waves in gases. W. C. GRIFFITH AND W. BLEAKNEY. *Amer. J. Phys.*, **22**, *No.* 9, 597–612 (*Dec.*, 1954).

This paper is in part a review but it also contains some original work. It deals with the manner in which shock waves are formed from finite compressions in gases and describes something of the

structure of the shock front itself. The principal features of the behaviour of shocks in reflection, refraction, and diffraction are discussed with particular attention given to anomalous observations and comparison with simple theories. Some results are given for shocks in real molecular gases showing relaxation effects. Quite a number of illustrations are included from the authors' own observations in the shock tube. The treatment is not exhaustive but covers many points likely to be of interest to teachers of physics. A.

534.23 : 532.7

807. Ultrasonic absorption in liquid mixtures. K. Eppler. Note in *Naturwissenschaften*, **41**, *No.* 16, 370–1 (1954) In German.

Anomalous absorption is investigated for several liquid mixtures. An attempt at explanation is made assuming that association occurs. T. C. TOYE

534.23 : 533.6

Pressure effects of relaxation and bulk viscosity in gas motion. *See Abstr.* 793

534.23 : 537.312.62

Ultrasonic attenuation in superconducting lead. *See Abstr.* 969

534.231.3

808. Acoustic admittance and impedance as vector quantities. J. S. Pyett. Letter in *J. Acoust. Soc. Amer.*, **26**, *No.* 5, 870 (*Sept.*, 1954).

Refers to papers by O. K. Mawardi [Abstr. 8598 (1951)] and W. Wilms [Abstr. 6379 (1954)] in which new definitions of specific admittance and impedance as vectors are proposed. The admittance vector $y = q/p$ (where p is the complex scalar acoustic pressure, and q is the complex vector particle velocity). The present paper discusses the physical significance of p and q, giving examples in illustration of travelling waves in a tube with rigid walls. A. B. WOOD

534.232

809. An exact method for determining the directivity index of a general three-dimensional array. E. Rhian. *J. Acoust. Soc. Amer.*, **26**, *No.* 5, 704–6 (*Sept.*, 1954).

An exact method for determining the directivity index of a general three-dimensional array with phased elements is described. The expression for the reciprocal of the directivity factor is shown to be a sum of terms which are simple functions of the sensitivity, phasing, and location of the elements of the array. As an example, the method is applied to a sixteen-element plane array. A.

534.232

810. Sound radiation from vibrating solids in accordance with the kinetic theory of gases. V. Gavreau and A. Calaora. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 20, 1272–4 (*Nov.* 15, 1954) In French.

The surface of a vibrating solid is not comparable with a surface of the wave of the sound it emits, for the molecules of the gas in a state of thermal agitation cross the surfaces of the wave but do not cross the surface of the solid. The authors calculate the change of velocity of the molecules which strike the solid surface, a piston which is vibrating sinusoidally—this change being equal to twice the velocity of the piston. As a consequence of this it is shown, in the case of air, that the intensity of sound emitted by a piston is only 87·6% of the value usually accepted. This has been verified by indirect experiment. According to Rayleigh the ratio of the pressure of radiation to the intensity of sound in air is 1·2. The authors, using the value of intensity derived from their new formula, obtain from measurements of radiation pressure a ratio 1·19. A. B. WOOD

534.39

811. Selective heating of a cylinder in a viscoelastic medium. J. F. Pink. *J. Acoust. Soc. Amer.*, **26**, *No.* 5, 870–1 (*Sept.*, 1954).

Obstacles exposed to ultrasonic radiation in a viscoelastic medium cause scattering of the waves and may cause selective heating of the medium. A first-order calculation is given which indicates that almost all of any selective heating results from the generation of highly damped scattered transverse waves at the obstacle. The analysis suggests that a reduction in thermocouple radius may bring about a significant reduction in selective heating and in temperature measurement error. G. F. HODSMAN

534.7

Physiological acoustics. Hearing. *See also under* "Medical science. Human physiology." Decimal classification 612.85

534.773.2

812. The mechanical impedance of the human mastoid process. R. S. Dadson, D. W. Robinson and R. G. P. Greig. *Brit. J. appl. Phys.*, **5**, *No.* 12, 435–42 (*Dec.*, 1954).

The main object of the work was to develop objective procedures for assessing the response characteristics of bone-conduction receivers, by providing data for the design of an "artificial mastoid" having a driving-point impedance simulating the average human mastoid. The design of such a device is in hand and will be reported in due course. A frequency range of 125–6200 c/s was covered which is rather wider than that currently utilized in hearing aids or audiometers operating by bone conduction. In the frequency band concerned the impedance of the average mastoid was found to be expressible simply as the impedance of the tissue layer backed by a rigid mass representing the inertia of the whole head. Equivalent electrical networks derived from the test results illustrate the dynamical properties of the system and their dependence on operating conditions such as the static contact force and the driven area. A short review of the small amount of comparable data reported by other authors is included. A.

534.79 : 53.081

813. On abbreviating "db re 0·0002 microbar". H. A. Thorpe. Letter in *J. Acoust. Soc. Amer.*, **26**, *No.* 5, 871 (*Sept.*, 1954).

Proposes to substitute "db T" (db Toepler) for the somewhat lengthy expression "db re 0·0002 microbar," on the grounds that Toepler was a pioneer in the measurement of the threshold of audibility of the human ear. A. B. WOOD

534.845

814. Improvement of efficiency of acoustic [absorbing] panels by resonators. G. Kurtze. *Tech. Mitt. PTT*, **32**, *No.* 3, 81–7 (1954) In German.

The use of acoustic absorbent panels has been

known for many years, as a means of reducing local noise and decreasing the reverberation time in auditoria. The present paper describes methods of increasing the efficiency of these panels by appropriate methods of mounting. By suitable arrangement it is possible to mount the panels to form resonant cavities—of known volume and size of neck (circular or slit Helmholtz types). In this way increased absorption occurs particularly in the region of low frequencies. A. B. WOOD

534.862.6

815. On the use of integrating and differentiating circuits in acoustic technique. A. FOCH, J. RATEAU AND R. COUNORD. Letter in *C.R. Acad. Sci.* [*Paris*] **239,** *No.* 7, 528–9 (*Aug.* 18, 1954) In French.

A brief description is given of the effects of introducing integrating and differentiating circuits into acoustic emission and reception systems. An integrating circuit, for example, transforms the vibration $A \cos \omega t$ into $(A/\omega) \sin \omega t$, thereby conserving the intensity of the pure tone, but weakening the harmonics, proportional to their number, by 6 db per octave. Such an effect produces a marked change in the intelligibility of speech and modifies the "timbre" of musical instruments and the singing voice. A second and a third integration makes speech become almost unintelligible. Differentiating circuits naturally produce the inverse effect, exaggerating the higher harmonics. Intelligibility is preserved much better than in integration—even five differentiations only reducing it to 93·6%. As a check it was found that a record, after 2 differentiations followed by two integrations, rendered the voice of a speaker easily recognizable. A. B. WOOD

OPTICS . RADIATION . SPECTRA 535

535.12

816. Under what conditions is the amplitude form of a laterally bounded wave complex? K. ARTMANN. *Ann. Phys.* [*Leipzig*] **15,** *No.* 1, 1–5 (1954) In German.

It is shown that in a laterally bounded light wave $A(l, b) \exp. ikl$, the amplitude form $A(l, b)$, if increasing laterally from zero to unity, cannot be real; it must have the form of the complex Fresnel integral. P. M. DAVIDSON

535.223

817. The group velocity of light in glass and calcite. E. BERGSTRAND. *Ark. Fys.*, **8,** *Paper* 45, 457–69 (1954).

The light modulator consisted of a standing ultrasonic wave set up in a piezo-quartz crystal. In the measurements with calcite, the group velocity at various inclinations to the optic axis was determined. The theory is discussed. P. M. DAVIDSON

535.233.5

818. A physical colour temperature comparator. W. J. BROWN. *J. sci. Instrum.*, **31,** *No.* 12, 469–71 (*Dec.*, 1954).

Describes the development and construction of a physical colour temperature comparator incorporating a rapidly rotating filter, red over one semicircle and blue over the other. The instrument has an accuracy of at least $\pm 2°$K throughout the colour temperature range 2360–3100°K. The range may be extended to higher and lower temperatures by colour temperature conversion filters, but at lower temperatures the accuracy decreases. A.

535.241

819. Standards of light. J. TERRIEN. *Bull. Soc. Franç. Elect.*, **4,** 463–8 (*Aug.*, 1954) In French.

Describes the primary standard and the steps by which secondary standards of luminous intensity and luminous flux at higher colour temperatures are derived from it [Abstr. 3080–1 (1953)]. Lamps are specially made in France for use as secondary standards. J. W. T. WALSH

535.245

820. A logarithmic photometer. H. L. GRANT AND R. W. STEWART. Note in *Canad. J. Phys.*, **32,** *No.* 10, 674–7 (*Oct.*, 1954).

Describes a photometer designed for rapidly determining the distribution of illumination along a line on a plane surface. A plate made up of a large number of opalescent Plexiglas strips separated by sheets of polished foil is placed with one face in the plane considered; the depth of penetration of the light in any strip being a linear function of the logarithm of the illumination on the surface of that strip, the distribution of illumination is obtained by photographing the face of the plate formed by the edges of the Plexiglas strips and printing on high-contrast paper. The instrument is calibrated by illuminating the plate with a source at various distances, giving a range of 400 to 1 in illumination. J. W. T. WALSH

535.3

821. Light paths in inhomogeneous, absorbing, isotropic media. F. CAP AND W. RÖVER. *Acta phys. Austriaca*, **8,** *No.* 4, 346–55 (1954) In German.

Fermat's principle is extended to the case of inhomogeneous and absorbing media. From Maxwell's equations, an expression similar to Fermat's principle is obtained, with the refractive index replaced by a function of the complex refractive index of the medium. R. W. FISH

535.317

822. Computation of achromatic objectives. R. E. STEPHENS. *Circ. Nat. Bur. Stand., No.* 549, 7 *pp.* (1954).

Procedures for the computation of the curves for achromatic doublet objectives by the algebraic method are presented in considerable detail, using the design of two such objectives as examples. The reasons for choosing particular pairs of glass types and the changes in procedure necessary to accomplish different degrees of correction are discussed. The information contained in this Circular is sufficient to guide the reader in computing algebraically achromatic objectives for his own specific applications. It also serves as an introduction to the algebraic method for those who may wish to delve further into the design of lens systems. A.

535.317

823. Field aberrations in wide aperture optical systems. W. S. S. Blaschke. *Proc. Phys. Soc.* [*London*] *B*, **67**, *Pt* 11, 801–10 (*Nov.*, 1954).

It is shown how the considerations which lead to the sine condition may be simply extended to take into account the aberrations which depend on the square of the field but include all powers of the aperture. In this way the relations known in primary aberration theory between pupil and image aberrations are reinterpreted and extended. The formulae are used to evaluate the field aberrations of a wide-angle high-numerical-aperture flat-field objective and comparison is made with the result of accurate trigonometrical calculation. A.

535.317.3/.5

824. The extension of the paraxial imagery region as a means of representing the aberrations of the image. C. Hackl. *Optik*, **11**, *No.* 10, 468–77 (1954) In German.

An alternative to the conventional method of developing aberration theory is given. The refracting surface is replaced by a neighbouring surface with the same vertex, perhaps by the tangent plane at the vertex. The extension of the paraxial equations to the refraction then requires a fictitious law of refraction. A comparison with the real law of refraction will then allow the aberrations to be determined. Examples of the method are given. R. W. FISH

535.317.7

825. An improved optical test for spherical aberration. J. B. Saunders. Letter in *J. Opt. Soc. Amer.*, **44**, *No.* 8, 664 (*Aug.*, 1954).

A modified Foucault test is described, using a narrow slit as a source and a filament to intercept the image of the slit. Using white light, highly coloured diffraction bands are seen to cover the mirror surface, except for a narrow white band near the centre of the shadow of the filament. The centre of the white band gives a more precise indication of the position of the zone sought than previous methods. Some practical details are given and a sample photograph. R. W. FISH

535.318

826. Out-of-focus diffraction patterns for microscope objectives. R. O. Gandy. *Proc. Phys. Soc.* [*London*] *B*, **67**, *Pt* 11, 825–31 (*Nov.*, 1954).

Formulae are derived for the diffraction pattern at the image plane of an out-of-focus point source, and an out-of-focus line source. The lens considered is an idealization of a microscope objective; it is assumed to be a flat-field anastigmat, and to subtend a small angle at the image, but no restriction is placed on the angle subtended at the object. A discussion is given of the assumptions required both for deriving and for applying the formulae, and some indication is given of the effect of the differences between practice and theory. A.

535.321 : 535.417

827. An interferometric method of measuring the dispersion of liquid and solid substances. I. N. Shklyarevskiĭ and V. K. Miloslavskiĭ. *Zh. tekh. Fiz.*, **24**, *No.* 8, 1387–91 (1954) In Russian.

The method is based on the use of fringes of equal chromatic order and results are given for methylene iodide, zinc sulphide and a dye solution over the whole visible spectrum. J. M. HOUGH

535.323

828. Index of refraction of fused-quartz glass for ultraviolet, visible, and infrared wavelengths. W. S. Rodney and R. J. Spindler. *J. Res. Nat. Bur. Stand.*, **53**, *No.* 3, 185–9 (*Sept.*, 1954).

For abstract, see Abstr. 10926 (1954).

535.329–14 : 535.343.4

829. Microwave dispersion in ammonia at 10^{-2} mm of Hg. B. D. Osipov. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 1, 115 (1954) In Russian.

Either the dispersion or the absorption of the $J = 6$, $K = 5$ line of NH_3 can be displayed according to the exact electrical position of the reflecting plunger in a system detector-oscillator-waveguide cell-plunger in order. D. H. WHIFFEN

535.33.07

830. Resolution and dispersion of a concave grating spectrometer using a photomultiplier detector. P. Fisher. Letter in *J. Opt. Soc. Amer.*, **44**, *No.* 8, 665 (*Aug.*, 1954).

For grazing incidence at $\lambda = 600$ Å, approximately theoretical resolution has been obtained.

G. F. LOTHIAN

535.33.07

831. Photoelectric spectrophotometer for the vacuum ultraviolet. Application to the study of reflecting powers. S. Robin. *Rev. Opt.*, **33**, *No.* 5, 193–228 (*May*); *No.* 8, 377–405 (*Aug.*, 1954) In French.

Describes the construction, adjustment and pumping system of a concave grating monochromator of resolving power about 40 000 in the 1st order. The source used is a high-voltage capillary discharge in hydrogen either with a LiF lens window or continuously pumped without window. Response curves for various experimental photocells are given for $\lambda = 1500$–3000 Å. For reflection measurements a commercial photomultiplier is used with a sodium salicylate fluorescent layer. Reflection factors are determined at incidence of 18° and 45° for 2 planes of polarization (obtained from measurements with unpolarized radiation reflected from 2 surfaces in series, reflections being in turn in the same plane and in perpendicular planes). Curves show reflection factors for $\lambda = 1100$–2000 Å for quartz, Pyrex, LiF, CaF_2, diamond, tungsten carbide, corundum, evaporated films of Be, Rh, Ni, Cr, Pt, Au, and electrolytically polished Al. The dielectrics and Be show a reflection max. Preliminary values of the optical constants of Cr, Pt and Au are plotted.

G. F. LOTHIAN

535.33.07

832. Logarithmic sector *vs.* photoelectric densitometer in measuring intensity ratios. M. Green and M. L. Polk. *Appl. Spectrosc.*, **8**, *No.* 3, 126–30 (*Aug.*, 1954).

The relative intensities of a group of ten lines of the spectrum of a hydrogen discharge tube have been measured both by conventional photoelectric densitometry and with a logarithmic sector. A statistical analysis of the results showed that, for the instruments used, photoelectric densitometry is slightly more

accurate than logarithmic sector intensitometry; the former method gave an average coefficient of variation in the measurement of an intensity ratio of 2%, whereas the latter method gave an average coefficient of variation of approximately 4%. However, for a great many applications in spectrochemical analysis the latter method appears to be sufficiently accurate, at the same time having many advantages. It is faster, simpler; intensity ratios are obtained directly without the need of a calibration curve; the method is self-calibrating; it does not involve a considerable amount of complicated equipment that requires frequent attention; intensity ratios can be made over a much greater range for a single exposure of the spectrum. A.

535.337 : 537.228.5

833. The Stark effect in hydrogen-like spectra. G. W. Series and K. W. H. Stevens. *Proc. Roy. Soc. A*, **226**, 393 (*Nov.* 23, 1954).

The theory is extended to the case in which levels with the same n and j are not degenerate. A formula is given for a Stark effect which is small compared with the separation between $nS_{\frac{1}{2}}$ and $nP_{\frac{1}{2}}$. A.

535.338 : 535.343.2

834. Shapes of absorption and emission lines of impurities in solids. D. L. Dexter. *Phys. Rev.*, **96**, *No.* 3, 615–16 (*Nov.* 1, 1954).

Existing treatments of band shapes in solids, for the simplest impurity centres, predict Gaussian shape functions. These treatments assume for simplicity that the electronic matrix element is independent of the nuclear wave-functions, and that the energy width of the band is negligible compared with the energy of the midpoint of the band. The expected magnitude of the effect of correcting these assumptions is estimated in typical cases, and it is found that the emission or absorption band may deviate from a Gaussian by 20% or more on the wings. A.

535.338.3

835. An extension of the normal series of the O I spectrum. G. Kvifte. *Arch. Math. Naturvid.*, **52**, *No.* 1–2, 65–8 (1954).

Part of the normal series of O I, i.e. $3p^3P$–ns^3S, $3p^5P$–ns^5S and $3p^5P$–n_1d^5D is found experimentally for n up to 13 and n_1 up to 12. G. E. Brown

535.338.32

836. The quenching of potassium resonance radiation by hydrogen and deuterium. W. M. Smith, J. A. Stewart and G. W. Taylor. *Canad. J. Chem.*, **32**, *No.* 10, 961–8 (*Oct.*, 1954).

The quenching of the resonance radiation of potassium by hydrogen and deuterium has been studied over the temperature range 71°C to 83°C. The quenching cross-sections at 76°C were found to be $1{\cdot}56\times10^{-16}$ cm^2 and $1{\cdot}10\times10^{-16}$ cm^2 respectively. A.

535.338.332

837. The fine structure of the line 4686 Å of singly ionized helium. G. W. Series. *Proc. Roy. Soc. A*, **226**, 377–92 (*Nov.* 23, 1954).

A liquid-hydrogen-cooled discharge tube similar to that formerly used in the investigation of the fine structure of the α-line of heavy hydrogen has now been used to reduce the Doppler width of the components of the line $n = 4 \rightarrow n = 3$ in the spectrum of He^+. The resolving power necessary to separate some components was obtained without sacrificing spectral range by using two Fabry–Perot etalons in series mounted externally to a prism spectrograph. For other components a single etalon was used. Eight components were resolved and their separations measured, and a ninth partially resolved. The positions of certain band lines of hydrogen and helium which lie close to the He^+ complex and overlap it in different orders of interference were also measured. The relative intensities of the components were broadly in agreement with the relative transition probabilities calculated from the Dirac theory, but some anomalies were observed. From the measurements it is deduced that some of the energy levels are displaced from the positions predicted by the Dirac theory: the $3S_{\frac{1}{2}}$ level upwards by $0{\cdot}140 \pm 0{\cdot}005$ cm^{-1}, the $4S_{\frac{1}{2}}$ level upwards by $0{\cdot}056 \pm 0{\cdot}003$ cm^{-1} and the $4P_{\frac{1}{2}}$ level downwards by $0{\cdot}011 \pm 0{\cdot}003$ cm^{-1}. These displacements of the $S_{\frac{1}{2}}$ levels are in good agreement with the predictions of the new theory of quantum electrodynamics, but the theory does not predict a displacement of the $4P_{\frac{1}{2}}$ level by this amount. The Stark effect could account for part of the discrepancy, but there remains a disagreement with the theory which exceeds the estimated experimental error. A.

535.338.333

838. Isotope shift in Hf I. J. A. Collinson. *Phys. Rev.*, **96**, *No.* 4, 949–51 (*Nov.* 15, 1954).

The hyperfine structure in $_{74}$Hf I lines has been resolved and found to consist of either a single line or a well-resolved doublet. The components of the doublets are attributed to isotopes 178 and 180. The magnitudes of these shifts have been determined using several independent measurements. The typical size of the doublet separations is about 0·035 K. The arrangement of the shifts indicates that the configuration responsible for seven low-energy levels is $5d^26s^2$. The structure due to isotopes 176, 177 and 179 is nowhere well resolved. A.

535.338.4

839. The blue band-system of niobium oxide. U. Uhler. *Ark. Fys.*, **8**, *Paper* 27, 265–79 (1954).

A new rotational analysis has been carried out. The bands are shaded to the red and represent a $^2\Delta$–$^2\Delta$ transition $[A^2$–$(X)^2\Delta]$. Both $^2\Delta$-states show a moderate multiplet splitting and have large γ-values. The 0, 0, 0, 1, 1, 2, 1, 0, 2, 1, 2, 0 and 3, 1 bands have been analysed. A.

535.338.4

840. The rotational analysis of the α and γ systems of zirconium oxide. A. Lagerqvist, U. Uhler and R. F. Barrow. *Ark. Fys.*, **8**, *Paper* 28, 281–93 (1954).

New rotational analyses of the 0, 0 bands of the α- and γ-systems of ZrO have been made. Earlier analyses, which led to an improbably small value of the internuclear distance, appear to be incorrect. The nature of the electronic states is discussed: it is concluded that states X and C are $^3\Delta$, state $A^3\Phi$. A.

535.338.4

841. The rotational analysis of the β-system of zirconium oxide. U. Uhler. *Ark. Fys.*, **8**, *Paper* 29, 295–304 (1954).

The 0, 0 band of the system β $(B$–$X)$ of zirconium

oxide has been made the subject of a rotational analysis. Λ-type doubling was observed in two of the three sub-bands and the transition was found to be $^3\Pi$–$^3\Delta$. A.

535.338.4 : 536.654

A thermodynamic and spectroscopic study of gaseous magnesium oxide. *See Abstr.* 909

535.343–15

842. Potassium bromide disk method for the infrared studies of coördination compounds. T. J. Lane, D. N. Sen and J. V. Quagliano. *J. chem. Phys.*, **22**, *No.* 11, 1855–6 (*Nov.*, 1954).

The infrared absorption of tetrakis (ethylenethiocarbamide) copper(I) nitrate, ethylenethiocarbamide, and potassium nitrate have been measured by the potassium bromide disk method. The assignment of the frequencies of ethylenethiocarbamide explains that part of the spectrum (the wavelength region between 7 and 13 microns) in which various CH_2 deformation frequencies are expected to appear. Generally speaking the infrared spectrum of tetrakis (ethylenethiocarbamide) copper(I) nitrate can be regarded as the superposition of the spectra of ethylenethiocarbamide and potassium nitrate, except for the absorption peaks at 9·6 and 14 microns, which do not appear in the infrared spectra of ethylenethiocarbamide and potassium nitrate. It is interesting to note that these wavelengths correspond to the Raman frequencies (1050 cm^{-1} and 720 cm^{-1}) of potassium nitrate, which should be infrared-inactive. The appearance of these frequencies in the absorption spectrum is explained by the distortion of the nitrate ion in tetrakis (ethylenethiocarbamide) copper(I) nitrate. A.

535.343.2 : 539.216

843. The near infra-red absorption spectra of natural and synthetic fibres. A. Elliott, W. E. Hanby and B. R. Malcolm. *Brit. J. appl. Phys.*, **5**, *No.* 11, 377–81 (*Nov.*, 1954).

The near infrared region may be used to obtain spectra with polarized radiation of natural and synthetic fibres. This region has considerable experimental advantages and the spectra of poly-*L*-alanine, polyglycine, wool, silks and commercial regenerated protein fibres are shown and discussed. Besides supplementing other types of observation, information may be obtained on the orientation and molecular configuration not always given by other methods. A.

535.343.2–15 : 539.132

844. Infrared spectra of CH_3COONa and CD_3COONa and assignments of vibrational frequencies. L. H. Jones and E. McLaren. *J. chem. Phys.*, **22**, *No.* 11, 1796–800 (*Nov.*, 1954).

The absorption spectra of solid CH_3COONa and CD_3COONa have been observed from 350 to 5000 cm^{-1}. All of the fundamental frequencies of the acetate ion have been observed and assigned with the exception of that of the torsional oscillation. The assignments for CH_3NO_2 and CD_3NO_2 were used as an aid in assigning the $CH_3CO_2^-$ and $CD_3CO_2^-$ frequencies. An approximate force constant, $9·3 \times 10^5$ dyne/cm, is given for the C–O bond of $CH_3CO_2^-$ in solid sodium acetate. The spectra of the partially deuterated species were observed and assignments were made with the aid of the Decius–Wilson sum rule and the Teller–Redlich product rule. A.

535.343.4–14

845. A method of measuring the coefficient of absorption in microwave radiospectroscopy. A. M. Prokhorov and A. I. Barchukov. Letter in *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 761–3 (1954) In Russian.

Since the 100 kc/s signal of a Stark effect microwave gas spectrometer is too small at 0·01% modulation depth for direct measurement, its voltage on an oscilloscope screen is compared, using the same amplifier, with a 5% modulated signal, which can be measured more accurately. This is obtained by beating a 100 kc/s signal with the Klystron in a multiplying head. An overall absolute accuracy of 10% is claimed. D. H. Whiffen

535.343.4–14

846. Microwave absorption spectra of MnO_3F and ReO_3Cl. A. Javan and A. Engelbrecht. *Phys. Rev.*, **96**, *No.* 3, 649–58 (*Nov.* 1, 1954).

Spectra near 1 cm wavelength were studied. From the spectra of the first molecule and its isotopic species $Mn(O^{16})_2O^{18}F$, the structural parameters were determined as: Mn — O = 1·586 Å, Mn — F = 1·724 Å, ∠(O, Mn, F) = 108°27′. The nuclear quadrupole coupling constant of Mn^{55} was measured as eqQ = 16·8 Mc/s. Because of the spin and statistics of O^{16} nuclei not all of the rotational states are allowed. It was found that, whereas in the ground vibrational states only states with K a multiple of three are permissible, in the excited vibrational states of the perpendicular normal modes the states with $K - l$ a multiple of three can occur. For $K = l = \pm 1$ appreciable l-type doubling was observed. The amounts of l-doubling and their corresponding values of α_v were determined for MnO_3F. The molecular dipole moment of this molecule was found to be $\mu = 1·5$ Debye units. The hyperfine structure of ReO_3Cl gives for the ratio of quadrupole moments of the two abundant isotopes of Re a value of $Q_{Re^{187}}/Q_{Re^{185}} = 1·067 \pm 0·045$ and for the quadrupole coupling constant of Re^{187}, $eqQ = 253$ Mc/s. This coupling constant and the known optical value of the quadrupole moment of Re^{187} give some information about the electronic structure of the molecular bonds, from which an approximate value of the nuclear quadrupole moment of Mn^{55} was obtained as $Q = 0·55 \times 10^{-24}$ cm^2. A.

535.343.4–14

847. Absorption of microwaves by oxygen in the millimeter wavelength region. J. O. Artman and J. P. Gordon. *Phys. Rev.*, **96**, *No.* 5, 1237–45 (*Dec.* 1, 1954).

Pressure broadening of the absorption lines near 60 000 Mc/s because of the oxygen molecule has been examined in pure oxygen, and in oxygen-nitrogen mixtures. The apparatus consisted of a large nonresonant cavity spectrometer, with bolometer detectors. At pressures of a few millimetres, a fairly constant $(\Delta\nu/P)$ value of 1·94 ± 5% (Mc/s) per mm Hg has been found for pure oxygen, independent of the rotational state of the molecule. To explain absorption in dry air at pressures from one-quarter to one atmosphere, a value of 0·75 for the broadening ratio of $(\Delta\nu/P)$ for O_2–N_2 to $(\Delta\nu/P)$ for O_2–O_2 accounts satisfactorily for the broadening effect of nitrogen. A theoretical analysis has been applied assuming the

important molecular interactions are the London dispersion (polarizability) and exchange forces. Dipole-dipole forces are absent, and quadrupole- and magnetic-dipole effects are found to be too weak to be effective. A.

535.343.4–15

848. An infrared band of a molecular complex between hydrogen fluoride and chlorine trifluoride. J. P. PEMSLER AND D. F. SMITH. *J. chem. Phys.*, **22**, *No.* 11, 1834–6 (*Nov.*, 1954).

A band at 2·57 μ wavelength has an absorbance which depends upon the product of the partial pressures of hydrogen fluoride and chlorine trifluoride and is hence attributable to a molecular complex $HF \cdot ClF_3$. This complex is present only in low concentration. The temperature variation per unit product of the pressures indicates a heat of reaction of 3·9 kcal per mole for the reaction $HF + ClF_3 \rightleftarrows HF \cdot ClF_3$. The band is a hydrogen–fluorine stretching vibration. The complex probably does not contain a hydrogen bond. A.

535.343.4–31

849. Absorption cross-sections in the vacuum ultraviolet. II. The Schumann–Runge bands of oxygen (2000 to 1750 Å). R. W. DITCHBURN AND D. W. O. HEDDLE. *Proc. Roy. Soc. A*, **226**, 509–21 (*Dec.* 7, 1954).

Absorption cross-sections for oxygen in the region 2000 to 1750 Å, corresponding to the process $O_2 X^3\Sigma_g^- + h\nu \rightarrow O_2 B^3\Sigma_u^-$ have been measured. The oscillator strengths for the vibrational transitions have been calculated from these results. The total oscillator strength (including the continuum) is found to be 0·259. The cross-sections for intermolecular collisions causing deactivation of the upper state are found and analysed. The (0–19) and (0–20) members of the system are observed, and the dissociation limit found to be 57 140 $\pm$ 20 *K*. A.

535.343.9–14 : 539.153

850. Redetermination of the hyperfine splitting in the ground state of atomic hydrogen. J. P. WITTKE AND R. H. DICKE. Letter in *Phys. Rev.*, **96**, *No.* 2, 530–1 (*Oct.* 15, 1954).

The zero field hyperfine splitting of ground state H atoms was determined in low pressures of H_2 and a weak, 0·06 gauss, 30 c/s modulating field in a TE_{112} cavity. The line of Lorentz shape had a width of 3 kc/s. The fully corrected frequency was $\nu_0 = 1420{\cdot}40580 \pm 0{\cdot}00005$ Mc/s which agrees with theory and is 0·0007 Mc/s higher than the molecular beam value. D. H. WHIFFEN

535.345

851. Optical and infrared absorption of copper at 4·2°K. M. A. BIONDI. Letter in *Phys. Rev.*, **96**, *No.* 2, 534 (*Oct.* 15, 1954).

Absorption by a single crystal and a polycrystalline target have been studied over the range $0{\cdot}5\mu < \lambda \leqslant 4\,\mu$, and were found to be in good agreement. For $\lambda > 2\,\mu$, the absorption was found to be largely independent of λ, suggesting diffuse electron reflection. Agreement with the theory for this type of reflection depends on the value of the effective electron mass m^*. It is good if $m^* = m$, and not so good if $m^* = 1{\cdot}4\,m$, as suggested by specific heat data. P. T. LANDSBERG

535.345

852. Optical and infrared volume absorptivity of metals. T. HOLSTEIN. Letter in *Phys. Rev.*, **96**, *No.* 2, 535 (*Oct.* 15, 1954).

Gives result of a quantum-mechanical treatment of electromagnetic absorptivity of metallic conduction electrons in optical and infrared region. It agrees with classical theory if the quantum of electromagnetic energy $\hbar\omega \ll kT$. The case $\hbar\omega \gg k\Theta \gg kT$ is discussed in greater detail, and improves agreement between theory and experiments on Cu at 4·2° K (cf. preceding abstract, choosing $m^* = 1{\cdot}4\,m$).

P. T. LANDSBERG

535.345 : 771.533

853. Spectral absorption in photographic emulsions. S. G. GRENISHIN. *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 736–43 (1954) In Russian.

Investigates absorption spectra (1) of colloidal particles of Ag metal, due to the effect of intense illumination in non-senzitized emulsions, (2) in emulsions which have been treated with a solution of KI, and (3) in emulsions subjected to secondary ripening. It is shown that a broad (400 mμ–1 μ) absorption band appears in emulsions which have been coloured by photochemical action. The position of maximum in this band depends on the properties of the emulsion. The second ripening brings about a new absorption band in the visible and infrared regions, with 2 maxima (400 and 800–900 mμ). Formation of AgI in AgBr emulsions shifts the maximum of the absorption band of Ag particles toward smaller wavelengths. F. LACHMAN

535.371

854. Quenching of photoluminescence of solutions. A. JABŁOŃSKI. *Acta phys. Polon.*, **13**, *No.* 3, 175–86 (1954).

The present theory is based on the following assumptions. The quenching molecules in solutions carry out constantly irregular oscillations about their actual equilibrium position, which they change from time to time. The frequency of changes of the equilibrium position depends *ceteris paribus* on the viscosity of the solution and of its temperature. To every distance of the equilibrium position of a quencher from that of the luminescent molecule belongs a certain time-proportional quenching probability. The above distance of the equilibrium positions is assumed to be discrete—the quencher may be present in the first, second and so on, shell constituted of the molecules of the solvent surrounding the excited luminescent molecule (the "shell model" of the luminescent centre). The behaviour of a system of such luminescent centres is described by a system of differential equations. The theory is applied to some simple cases, and expressions are obtained describing the decay of the total (i.e. emitted in all directions) photoluminescence intensity as well as expressions giving the quantum yield of photoluminescence as a function of concentration of quenchers and other factors. Apart from quenching by quenchers also the "inner quenching" of luminescent molecules and the quenching during the "initial shock" (disturbance in the motion of nuclei in the centre caused by electronic transition and lasting a very short time) are taken into account in

these expressions. The problem in question is solved rather generally for the case of solid solutions in which the equilibrium positions of the quenchers do not change. Only approximate expressions are obtained for the more involved case of liquid solutions. Several expressions given so far by different writers result as particular approximations from the present theory. A.

535.371

855. Temperature dependence of the luminescence and chemical stability of basic magnesium arsenate activated with tetravalent manganese. H. A. KLASENS. *Philips Res. Rep.*, **9**, *No.* 5, 377–90 (*Oct.*, 1954).

The effect of activator concentration and partial substitution of the lattice constituents by other ions on the temperature dependence of the luminescence of 6 $MgO \cdot As_2O_5 - Mn$ is studied. The effect of the activator concentration is in agreement with the theory of Johnson and Williams. Incorporation of lithium improves the temperature dependence considerably. Measurements of the stability of various arsenates in reducing atmospheres show that phosphors containing lithium are less easily reduced. Incorporation of fluorine has the opposite effect. A theory for this induced variation of stability is given. A.

535.371

856. Cathodo-luminescence of MgO. B. D. SAKSENA AND L. M. PANT. *Proc. Phys. Soc.* [*London*] *B*, **67**, *Pt* 11, 811–16 (*Nov.*, 1954).

The cathodo-luminescence spectra of different samples of MgO—fresh, previously exposed to cathode rays, heated in a Bunsen and oxy-coal-gas flame, show different characteristics. For the fresh crystal there is a strong band with peak at 4550–4400 Å which weakens in intensity as the crystal receives increasing previous exposure to cathode rays. At the same time three bands in the red–yellow region get increasingly stronger. On heating the exposed crystal, the previous condition (the same as that of the fresh crystal) is restored except for an increase of luminescence in the ultraviolet. The phosphorescence and the fluorescence spectra are the same for the fresh crystal, but for the crystal heated after previous exposure to cathode rays the fluorescence spectrum extends farther into the ultraviolet than the phosphorescence spectrum. The spectra of heated samples also show marked differences from the spectrum of the fresh crystal, and in the case of the sample heated in an oxy-coal-gas flame a new band at 2450 Å is obtained which disappears on continued cathode-ray bombardment. A.

535.371

857. Luminescence characteristics of some scintillating crystals. J. R. COOK AND K. A. MAHMOUD. *Proc. Phys. Soc.* [*London*] *B*, **67**, *Pt* 11, 817–24 (*Nov.*, 1954).

The phosphorescence observed during the period 2 to 400 μsec following the absorption of γ-ray photons has been studied in crystals of sodium iodide and potassium iodide (thallium activated) and calcium tungstate. The integrated light output is found to vary with temperature over the range −180°C to +15°C in a complex manner differing with each crystal. On the other hand, the decay time of the after pulses is to a first approximation temperature independent, with a decay constant in these particular crystals of around 15 μsec. It is concluded that a temperature dependent dissipative process occurs at some time during the initial decay, and is followed by the decay to a ground state with a time constant independent of temperature. A.

535.371 : 532.7

858. Magnitude of excitation energy and energy transfer by collision. M. FURST AND H. KALLMANN. *Phys. Rev.*, **96**, *No.* 4, 902–3 (*Nov.* 15, 1954).

Energy transfer by collision in fluorescent solutions is found to drop sharply when the excitation energy of the solute molecule is very close to or below that of the transferring molecule. The results indicate that energy is transferred only when molecules are close to each other as in collision. A.

535.371 : 548.7

859. Luminescence of *F*-centres in alkali-halide crystals. T. P. J. BOTDEN, C. Z. VAN DOORN AND Y. HAVEN. *Philips Res. Rep.*, **9**, *No.* 6, 469–77 (*Dec.*, 1954).

Crystals of KCl, KBr, KI, NaCl and RbCl coloured additively have been irradiated in the *F* absorption band at liquid-hydrogen and liquid-nitrogen temperatures. In all crystals an infrared luminescence has been observed between about 1 and 1·5 μ. The luminescence is quenched at temperatures above 100–150°K. The quantum efficiency is very low and the luminescence only appears when the crystals are kept at low temperatures after the formation of the *F*-centres and quenching in liquid nitrogen. Different results are obtained when the crystals are kept at room temperature in the dark or during irradiation. It is believed that the infrared emission is to be ascribed to *F*-centres. A.

535.372

860. The phosphorescence spectra of naphthalene and some simple derivatives. J. FERGUSON, T. IREDALE AND J. A. TAYLOR. *J. Chem. Soc.*, **1954**, 3160–5 (*Sept.*).

A photomultiplier technique was used to measure the phosphorescence emission. The spectrum of naphthalene is interpreted in terms of known vibration frequencies and an explanation advanced for the appearance of b_{1g} fundamentals. The reduction in the symmetry of the parent molecule brought about by simple substitution, causes marked changes in the spectrum, which are explained in some detail. A.

535.375.5

861. The Raman spectra of *m*- and *p*-xylene in the solid state at different low temperatures. D. C. BISWAS. *Indian J. Phys.*, **28**, *No.* 7, 303–11 (*July*, 1954).

The spectra in the liquid state and in the solid state at different low temperatures were recorded. Both the substances in the liquid state yield a few feeble extra Raman lines not reported in earlier publications. Some of the prominent Raman lines of both these compounds shift slightly with solidification of the compounds, but the number of lines undergoing such changes in their frequency-shifts is much greater in the case of *m*-xylene than in the case of the para compound. Three new lines appear in the low-

frequency region when the meta compound is solidified while two such lines in the low frequency region appear in the case of the para compound. With lowering of temperature of the solidified mass to −180°c the low-frequency lines of the former substance show little change except that the band at 81 cm^{-1} shifts to 90 cm^{-1} while in the case of the other compound the number of low-frequency lines increases from two to five with the lowering temperature to −180°c. The probable origin of these low frequency lines is discussed. The difference in the Raman spectra of these two isomers in the solid state is explained by assuming that the influence of the intermolecular field on the molecules of the substance depends on the relative positions of the substituent groups in the benzene ring. A.

535.375.5

862. On the Raman spectra of styrene and polystyrene at −180°c. N. K. Roy. *Indian J. Phys.*, **28**, *No.* 8, 365–70 (*Aug.*, 1954).

The Raman spectrum of monomeric styrene solidified and cooled down to −180°c has been recorded and compared with that obtained for the substance at room temperature. It is observed that in the case of the monomer the intensity of the line 1630 cm^{-1} diminishes slightly, but that of the line 772 cm^{-1} diminishes considerably with solidification and lowering of temperature to −180°c. The C–H valence oscillations also undergo some changes. It is pointed out that the lines 772 cm^{-1} and 1630 cm^{-1} disappear completely and the intensities of some other fainter lines diminish considerably with polymerization of the liquid. When the polymer is cooled to −180°c no further change in the Raman lines takes place, but two fluorescence bands appear at 4260 Å and 4556 Å respectively. The monomer at −180°c yields four sharp new lines in the low-frequency region and a corresponding wing is also observed in the Raman spectrum of the polymer at room temperature. These results have been discussed in detail. A.

535.375.5

863. The application of the Raman effect to the study of resinous acids. Le-Van-Thoi. *J. Phys. Radium*, **15**, *No.* 10, 699–702 (*Oct.*, 1954) In French.

535.375.5 : 535.343–15

864. Raman and infrared spectra of CF_3Br and CF_3I. W. F. Edgell and C. E. May. *J. chem. Phys.*, **22**, *No.* 11, 1808–13 (*Nov.*, 1954).

The Raman spectra have been obtained at −100°c and −40°c, respectively. The infrared spectra have been obtained at 30°c, and some measurements have been made at 160°c. The observed frequencies were assigned to the fundamental modes of vibration, their combinations and differences. The frequencies were interpreted in correlation with other CF_3X molecules in terms of the pertinent "natural" frequencies of vibration. A.

535.375.54

865. Vibrational spectra of molecules and complex ions in crystals. VII. The Raman spectrum of crystalline ammonia and 3-deutero-ammonia. F. P. Reding and D. F. Hornig. *J. chem. Phys.*, **22**, *No.* 11, 1926–8 (*Nov.*, 1954).

For previous part, see Abstr. 6382 (1951). The Raman spectra of crystalline NH_3 and ND_3 were measured at −82°c, using Hg 2536·5 Å exciting radiation. The fundamentals ν_1, ν_2 and ν_3 were observed, but ν_4 was not. ν_2 was split into two components by intermolecular coupling. Lattice frequencies of both translational and rotational origin were observed, and there was evidence of very little coupling between them. A.

535.376

866. Electroluminescence with nonsinusoidal fields. S. Nudelman and F. Matossi. *J. Electrochem. Soc.*, **101**, *No.* 11, 546–53 (*Nov.*, 1954).

Electric fields in the form of square or rectangular waves, saw-tooth waves, and exponential waves were applied to an electroluminescent phosphor. The light output contained green and blue luminescence bands, which were examined separately by means of filters, a photomultiplier, and an oscilloscope. Square wave fields produce luminescence peaks whenever the field is changing, followed by a decline in luminescence when the field is steady. Peak heights increase proportionally to about the fourth power of the field strength. They decrease with increasing frequency for the green band, while for the blue band they first increase up to about 2000 c/s and then decrease. The decay obeys power laws with different exponents before and after a critical time of about 0·7 msec. A rectangular field pulse of greater duration than the critical time produces, in the green band, peaks of equal total intensity at the field reversals; in the blue band, the same excitation produces peaks with equal changes in intensity. Other field shapes produce peaks of luminescence whose heights and shapes depend on field shape and duration of the steady field before it is changed. Additional peaks in the green band appear whenever the field begins to decrease. Observations are interpreted by using the following assumptions: excitation is due to collision processes of accelerated electrons; green luminescence involves transitions to the conduction band and to traps; blue luminescence is caused by transitions within a luminescence centre; the effective field changes in time because of the development of polarization charges. Additional peaks in the green band are due to recombination processes of the polarization charges. A.

535.376

867. Fluorescent response of NaI(Tl) to nuclear radiations. F. S. Eby and W. K. Jentschke. *Phys. Rev.*, **96**, *No.* 4, 911–20 (*Nov.* 15, 1954).

The dependence on thallium concentration of the fluorescent response of NaI(Tl) to γ-rays and charged particles has been examined for crystals containing known mole fractions of Tl in the range from 0·00006 to 0·008. Scintillations were detected with a photomultiplier tube and pulses were displayed on an oscilloscope and recorded photographically. Plots of integrated pulse height v. energy for α-particle excitation show a region of nonlinearity which decreases with increasing Tl concentration. At sufficiently high α-particle energies a linear relation is approached for all crystals. No deviations from linearity were observed in plots of pulse height v. energy for deuterons or protons in crystals containing a Tl mole fraction of 0·0013. The fluorescent efficiency

increases sharply with Tl concentration for mole fractions smaller than about 0·0015 and decreases for higher concentrations, this behaviour being more pronounced for deuteron than for α-particle excitation. Four separate decay processes characterize the pulse shapes. In addition to the main part of the pulse, which has a rise time (mean life) of about $5{\cdot}9\times10^{-8}$ sec and a long, concentration dependent, exponential decay (decay constant $2{\cdot}3$ to $3{\cdot}5\times10^{-6}$ sec, independent of exciting radiation), there are two faster decays: (1) an emission with a decay constant of $1{\cdot}2\times10^{-8}$ sec from crystals containing Tl mole fractions less than about 0·0002; and (2) a $1{\cdot}5\times10^{-8}$ sec decay from high-Tl-content crystals excited by particles having a large specific energy loss. The emission spectrum consists of two bands centred at about 3500 Å and 4100 Å, their exact positions depending upon the Tl concentration and shifting toward longer wavelengths with increasing Tl concentration. The $1{\cdot}2\times10^{-8}$ sec emission is from the short wavelength band, and the other emissions are from the band at 4100 Å. The dependence of the integrated pulse height on the Tl concentration and specific energy loss of the exciting particle are discussed, and possible explanations of the various decay processes are suggested. A.

535.41 : 548.24

868. The structure and optical behaviour of iridescent calcite. C. V. Raman and A. K. Ramdas. *Proc. Indian Acad. A*, **40**, *No.* 1, 1–7 (*July*, 1954).

Arrays of multi-coloured images of a distant light-source arranged in geometric patterns are exhibited by calcite rhombs traversed by twinning layers in several directions simultaneously. The paper reproduces four photographs of such patterns and also discusses the theory of the reflection and refraction of light by twinning layers in calcite. The large difference between the ordinary and extra-ordinary dispersive powers results in a linear source observed through such a layer appearing drawn out into spectra channelled by interferences. Interference bands also fringe the sharply defined boundaries seen separating the different parts of the optical field of reflection and refraction. A.

535.412

869. Note on localised and non-localised interference fringes. M. M. Nicolson. *Proc. Leeds Phil. Lit. Soc.*, **6**, *Pt* 3, 119–26 (*Feb.*, 1954).

The textbook discussions of localized and non-localized fringes in terms of "division of amplitude" and "division of wavefront," etc., are shown to be inadequate. In the air wedge interference experiment, which is an example of "division of amplitude," it is shown that non-localized fringes appear when a single slit source is used; that these fringes disappear in general when an extended source replaces the slit; that in a certain surface the fringes superimpose without confusion and hence give rise to localized fringes; and finally that the surface of localization is, in good approximation, the plane through the vertex of the wedge perpendicular to the line of sight. In the bi-mirror experiment, which is an example of "division of wavefront," the absence of localized fringes with an extended source can be traced simply to the fact that the surface in which they might be expected lies outside the region traversed by the two sets of reflected waves. Finally, it is shown by means of a familiar example that division of wavefront can lead to localized fringes. A.

535.417

870. Refractivity measurements on thick plates. J. B. Saunders. *J. Res. Nat. Bur. Stand.*, **53**, *No.* 3, 165–71 (*Sept.*, 1954).

An interferometer is described that permits measurement on refractive gradients in thick transparent bodies. The order of interference does not depend upon the thickness of the specimen. Any monochromatic light source may be used to test plates of any thickness. A 10 in. aperture interferometer of this type has been constructed and used successfully to measure index gradients in thick glass disks. A.

535.417 : 536.48

Multiple beam investigation of liquid helium in narrow gaps. *See Abstr.* 898

535.42

871. A new duality principle in optics. A. Lohmann. *Optik*, **11**, *No.* 10, 478–88 (1954) In German.

The principle of interchangeability of certain optical concepts is shown to be based upon the Fourier reciprocity of Fraunhofer diffraction. Examples from optics are given and compared with examples from a wider field of physical concepts. R. W. FISH

535.42

872. The deformation of a wave surface by a screen. M. Axelrad. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 13, 757–9 (*Sept.* 27, 1954) In French.

The deformation of a plane wave by the edge of a razor blade has been examined by means of an interference microscope with a numerical aperture NA = 1. The deformations are found to be less than $\lambda/20$.

R. W. FISH

535.43

873. On the intensity-distribution in the wing of the Rayleigh line due to liquid oxygen. G. S. Kastha. *Indian J. Phys.*, **28**, *No.* 7, 329–34 (*July*, 1954).

The intensity-distribution in the wing accompanying Rayleigh radiation from liquid oxygen has been studied quantitatively by the method of photographic spectrophotometry, using a suitable spectrograph and Hg 4047 Å line as exciting radiation. It has been shown that the intensity distribution in the wing shows a clear maximum at about 40 cm^{-1} from the centre of the exciting line and the intensity, instead of increasing continuously as the centre of the line is approached, falls off and becomes zero at a distance of 9 cm^{-1} from the centre of exciting line. The probable causes of the discrepancy between this result and that reported by Crawford *et al.* (1952) have been discussed. A.

535.43 : 539.215.08

874. Survey of scattering and absorption of light by particles. C. N. Davies. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 64–S 65 (1954).

The diffraction approximation and exact Mie theory, for treating light scattering by particles, are briefly compared for different sizes. Attention is drawn to the simplification of the screening function

which occurs if the particles are opaque. Methods of measuring small particles in the presence of large ones are discussed and reference is made to new techniques for measuring particle concentration. A.

535.43 : 539.215.08

875. Light scattering by polydisperse dust clouds. J. McK. Ellison. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 66–S 71 (1954).

When light is scattered by a cloud of particles of a wide range of sizes, the intensity scattered in any direction is built up from the contributions of particles of all dimensions. For forward scattering the relative values of these contributions have been calculated as a function of diameter, by two different approximate formulae for the angular distribution of the light scattered by spheres. The approximations used are: (1) that of Rayleigh and Gans, and (2) Kirchhoff diffraction by opaque circular disks. For the latter, the scattering by a cloud of disks whose diameters are log-normally distributed with a standard geometric deviation of 2·03 has also been computed. It is concluded that the predominance of the light scattered by larger particles limits the usefulness of light scattering as a means of obtaining a mean particle size to suspensions containing a comparatively narrow range of particle sizes. A.

535.43 : 539.215.08

876. Photoextinction measurements on spherical particles. P. C. Lewis and G. F. Lothian. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 71–S 75 (1954).

Experimental determinations, in the wavelength range 0·4–2·0 μ, of the transmissions of suspensions of spherical particles (barium sulphate and spores of *Lycoperdon pyriforme*) are used to calculate values of the total scattering coefficient K. The results are in approximate agreement with theoretical expectations. The measurements can also be used to determine the refractive indices and in certain cases the water content of the spheres. A.

535.43 : 541.18 : 531.7

877. An absorption-extrapolation light scattering method. F. W. Billmeyer, Jr. *J. Amer. Chem. Soc.*, **76**, *No.* 18, 4636–9 (*Sept.* 20, 1954).

The particle size of a polystyrene dispersion has been determined by a light scattering method in which transmission measurements are made as a function of wavelength. The data are extrapolated to infinite wavelength, where the usual small particle light scattering treatment is valid. The results are in satisfactory agreement with the size determined by other light scattering methods. A.

535.434 : 535.51

878. Elliptic polarisation of light scattered by colloidal solutions. R. S. Krishnan, P. S. Narayanan and S. R. Sivarajan. *Proc. Indian Acad. A*, **40**, *No.* 3, 140–50 (*Sept.*, 1954).

By an analysis of the theoretical conclusions of Mie's theory concerning the elliptic polarization of the scattered light when the incident light is plane polarized in an arbitrary azimuth, the significance of the phase difference between the vertical and the horizontal components has been pointed out. It has been shown how the experimental investigations so far carried out have failed to bring out clearly the implications of Mie's theory. Using suitable experimental methods to analyse the scattered radiation in some emulsions and monodisperse sulphur sols containing particles which were spherically symmetric and of uniform size, the constancy of the phase difference has been established by three different methods of measurement. The value of the phase difference calculated from the available Mie scattering functions for one sulphur sol agreed well with the measured value and the characteristics of the transversely scattered elliptically polarized light for different azimuths of polarization of the plane-polarized incident light, were in accordance with the predictions of Mie's theory. A.

535.55

879. A new device for half-shadow compensation in photo-elasticity. P. Tegelaar and R. G. Boiten. *Appl. sci. Res. A*, **5**, *No.* 1, 65–75 (1954).

A simple optical device is described, which can be attached to the analyser and which makes the photo-elastic bench suitable for measurements with the half-shadow method. A.

535.551

880. Photoelastic effects in microscopic fibres. A. J. Cruise. Letter in *Nature* [*London*] **174**, 923–4 (*Nov.* 13, 1954).

Fairly high pressures have been applied to cotton and nylon fibres by a process briefly described, in which the behaviour of the fibres may be watched. Optical path differences are produced by reflection and give rise to stress fringes. No polarizers are required. A typical pattern is shown and discussed. H. G. Jerrard

535.56–14 : 538.614

881. The Faraday effect at centimetre wavelengths. N. Neprimerov. Letter in *Zh. éksper. teor. Fiz.*, **26**, *No.* 4, 511 (1954) In Russian.

Rotations of plane-polarized 3·18 cm radiation up to 2° have been observed for $CuSO_4 . 5H_2O$, $MnSO_4$, etc., near the resonance field of $\sim$ 3000 gauss., using a waveguide reflection technique. D. H. Whiffen

535.7

Physiological optics. Vision. *See under* "Medical science. Human physiology." Decimal classification 612.84

535.823.5

882. Application of the phenomenon of light interference for determining the "noise level" of the microscope stage. Zh. S. Takibaev and V. N. Shakhvorostov. Letter in *Zh. éksper. teor. Fiz.*, **26**, *No.* 4, 507–8 (1954) In Russian.

The measured mean angle of multiple Coulombic scattering of emulsion particles (used in the investigation of cosmic radiation) differs from the true angle by the mean angle of spurious scattering, the latter being due to different causes: experimental error, asymmetry of grain distribution, and deviations of the mechanical (co-ordinate) microscope stage from rectilinear motion. The value of this deviation is called the "noise level," and a method is described for its determination with the use of Linnik's micro-interferometer and a plane mirror attached to the

stage at an angle of $\phi = w/2$ (where w is the convergence angle of the interference rays). The magnitude of the "noise level" is given by the value of displacement (in μ) of the interference image. The method suggested is sensitive to variations in temperature and humidity and to accidental vibrations.

F. LACHMAN

535.823.5

883. Measurements of the "noise" of different types of microscope stages. K. GOTTSTEIN. *Nuovo Cimento*, **12**, *No.* 5, 619–29 (*Nov.*, 1954).

The "stage-noise" of seven different microscopes (Cooke M 4000, Leitz Ortholux, Leitz Koordinatenkomparator. Zeiss Standard, Koristka M.S.2) was measured interferometrically. The variation of "stage-noise" with cell-size has been investigated, and the possibilities for the elimination of "noise" from the results of scattering measurements are considered. The minimum cell-sizes required with the different types of microscopes to obtain scattering angles significantly greater than "noise" are tabulated for protons of three energies. A.

535.824.1 : 539.215.08

Design of a microscope eyepiece graticule for routine dust counts. *See Abstr.* 1269

535.825.3

884. A simple microscope attachment for observing high-temperature phenomena. J. H. WELCH. *J. sci. Instrum.*, **31**, *No.* 12, 458–62 (*Dec.*, 1954).

The apparatus consists of a small, electrically heated thermocouple bent into a loop at its extremity so as to hold the specimen, in the form of a bead, in contact with the thermojunction. It is based on the apparatus described by Ordway [Abstr. 7675 (1952)], but has new and simpler electrical arrangements. For convenience, the bead is normally observed through a 25 mm microscope objective, though a 16 mm objective (5 mm working distance) can be used without any special precautions. The heating current is taken from any convenient 50 c/s supply and a vibrating switch driven from the same supply permits the heating current to flow only during alternate half-cycles, the measuring circuit being employed during the intermediate half-cycles. The power dissipated by the heater at maximum temperature (1750°c) is only about 6 W. The apparatus gives extremely rapid results in comparison with normal techniques when put to such uses as melting-point determinations, studies of glass devitrification, growing single crystals for X-ray structure determinations, and delineation of phase equilibria; it should find widespread application in the fields of glass and ceramic technology. A.

HEAT 536

536.2

885. Heat conduction in an infinite cylindrical medium with heat generated by a chemical reaction. P. L. NICHOLS, JR AND A. G. PRESSON. *J. appl. Phys.*, **25**, *No.* 12, 1469–72 (*Dec.*, 1954).

The non-linear partial differential equation for heat conduction in an infinite cylinder with heat generated by a chemical reaction has been solved by means of an electronic differential analyser. Solutions of the equations in dimensionless variable form have been obtained for a zero-order heat-release term and a first-order heat-release term. Altogether 162 solutions were obtained covering a range of activation energies from 10 to 20 kcal/mole. Empirical relations have been derived for the maximum temperature at the centre of the cylinder as a function of the experimental variables involved. Also relations relating to the approximate completion of reaction in terms of the experimental variables were derived from the tabulated data. Several calculations were made to demonstrate the general nature of the numerical solutions. A.

536.2.01

886. Contributions to the theory of thermal conduction of anisotropic solids. N. V. MITSKEVICH. *Zh. éksper. teor. Fiz.*, **26**, *No.* 5, 557–61 (1954) In Russian.

The differential equation of thermal conduction, its solutions in terms of Fourier series and alternative standard solutions are presented in a form applying to anisotropic bodies. R. EISENSCHITZ

536.2.01 : 537.311.33

887. On the theory of equation of transfer in a strong electric field. I. G. M. AVAK'YANTS. *Zh. éksper. teor. Fiz.*, **26**, *No.* 5, 562–75 (1954) In Russian.

Examines the transport of heat and electricity in semiconductors when the electron (or hole) gas is strongly warmed up in the electric field connected with the passing of current through the semiconductor. Explores the equations for currents of heat and electricity in a form suitable to verify this and a common formulation of the thermoelectric and galvomagnetic effects. W. BARDSLEY

536.2.01 : 537.311.33

888. On the theory of equation of transfer in a strong electric field. II. G. M. AVAK'YANTS. *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 668–79 (1954) In Russian.

Using equations developed in Pt I a common formulation of the thermomagnetic and the photomagnetic effect is obtained. Certain singular effects concerning the transport of heat and electricity in semiconductors in strong electric fields are explained. W. BARDSLEY

536.2.083

889. Determination of thermal conductivities at high temperatures. K. S. KRISHNAN AND S. C. JAIN. *Brit. J. appl. Phys.*, **5**, *No.* 12, 426–30 (*Dec.*, 1954).

The usual electrical methods of determining thermal conductivities either cannot be used at high temperatures or their use is restricted to substances like carbon or graphite which satisfy certain special requirements. It is shown that the observed temperature distribution along a metal filament electrically heated in a vacuum can be used for the determination of the thermal conductivity at high temperatures. The temperature distribution near the centre of a short filament, which is known to be parabolic, or the distribution in regions slightly removed from the centre of a long filament, which is known to be logarithmic, are particularly suitable for this purpose. Measurements are reported on the thermal conductivity of platinum in the temperature region 1300 to 1800°K made in this manner. A.

536.212.2 : 539.211

890. A theoretical investigation of the temperature distribution in the metal cutting process. A. C. RAPIER. *Brit. J. appl. Phys.*, **5**, *No.* 11, 400–5 (*Nov.*, 1954).

The problem investigated involves consideration of the temperature distribution in a body moving relative to sources of heat. Relaxation and analytical methods of solution have been developed and applied to the work material, the chip and the tool considered as three separate problems. The results obtained have been compared with other analytical solutions and with indirect experimental evidence of the temperatures attained. The application of the methods has been restricted to the simplest ideal model of the cutting process. The methods may be modified to incorporate the effect of temperature on the thermal properties, yield stress, etc., of the work material and are capable of a wider application to analogous heat flow problems. A.

536.25 : 538.65

891. On the inhibition of convection by a magnetic field. II. S. CHANDRASEKHAR. *Phil. Mag.*, **45**, 1177–91 (*Nov.*, 1954).

The analysis contained in Pt I [Abstr. 6456 (1952)] on the inhibition of thermal convection by a magnetic field is extended to include the case when the impressed magnetic field (**H**) acts in a direction different from that of gravity (**g**). A variational method is described for determining the critical Rayleigh number for the onset of convection of any preassigned pattern; and the result is established that when **H** and **g** act in different directions the convection which appears at marginal stability is in the form of rolls extended in directions parallel to the plane containing **H** and **g**. A.

536.413

892. Thermal expansion of lithium, 77° to 300°K. W. B. PEARSON. *Canad. J. Phys.*, **32**, *No.* 11, 708–13 (*Nov.*, 1954).

Measurements of the lattice parameters of lithium at temperatures below 300°K have been made and the results are compared with previous work and considered in terms of the Grüneisen relationship. Methods of low temperature X-ray photography are also discussed. A.

536.413.2 : 548.7

The thermal expansion of crystals. *See Abstr.* 1347

536.423.4

893. An investigation of the performance of the diffusion-condensation chamber. V. K. LYAPIDEVSKIĬ AND YU. A. SHCHERBAKOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 1, 103–9 (1954) In Russian.

An experimental study of the temperature distribution in a rectangular 20×30 cm air-alcohol chamber (height 19 cm) operating at 1 atm. between −60°C and 15 or 60 °C. The variation of the temperature gradient with height is due to heat exchange with the walls and can be controlled by changing the surrounding temperature. This does not disturb the stability of the functioning and can be used to vary the thickness of the sensitive layer. In particular the temperature gradient becomes constant if the walls are insulated. W. J. SWIATECKI

536.423.4

894. Water vapor condensation process in supersonic nozzles. P. P. WEGENER. *J. appl. Phys.*, **25**, *No.* 12, 1485–91 (*Dec.*, 1954).

The history of experimental and theoretical investigations of water vapour condensation phenomena in supersonic nozzles is reviewed. It is then shown empirically for a given experiment that the shocklike disturbance visible in flow pictures delineates the collapse of the supercooled state of the water vapour present in the air. All flow properties are calculated through this extended condensation zone from pressure distribution measurements, and it is seen that no shock waves are involved in the process. Finally a conversion of these data to an equivalent constant-area flow reveals that the latter would be an example of a weak detonation observed in nature as predicted by Burgers and by Reed. A.

536.48

895. Properties of solutions of He^3 in He^4. III. Vapour pressure. B. N. ESEL'SON. *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 744–50 (1954) In Russian.

For Pt II, see Abstr. 6929 (1951). The difference of saturation pressures over pure He^4 and a solution was measured by means of a differential manometer. Care was taken to repeat readings till they became time independent and, as the author assumes, represent equilibrium values. The times necessary for arriving at steady readings were 4 and 15 min. respectively for solutions below and above the λ-point. Measurements were made at a large number of temperatures between 1·3 and 3·1°K; six different solutions with concentrations between 0·49 and 8·08% were investigated. Results are compared with values calculated according to Henry's law; systematic deviations are found. The slope of the calculated curves is greater and they intersect with the observed curves at one temperature which decreases with increasing concentration. R. EISENSCHITZ

536.48

896. Rôle of exchange forces in the problem of helium II. S. FRANCHETTI. *Nuovo Cimento*, **12**, *No.* 5, 743–68 (*Nov.*, 1954).

Appropriate one-particle eigenfunctions are built up for excitons in liquid He which are quadratic in momentum and the exchange and "Coulomb" integrals for such eigenfunctions are studied. Independently, an analysis of experimental data concerning the energy absorbed per exciton in the interval from 0°K to the λ-point shows that the exchange energy must on the average be small. It is then shown that the exchange integral (in contrast with the "Coulomb" integral) cannot have a constant value but must increase with temperature, unless some appropriate mechanism prevents it from doing so. Though not analysing in detail such mechanism, an attempt is made to show that it must be the same which is responsible for the negative expansion between 1°K and the λ-point. Other topics touched upon are effective masses, excitation energies, and the behaviour of a saturated phonon gas. A.

536.48

897. Orthobaric densities of He^3 1·3°K to 3·2°K. E. C. KERR. *Phys. Rev.*, **96**, *No.* 3, 551–4 (*Nov.* 1, 1954).

Saturated liquid and vapour densities of He^3 have

been measured by a direct method in the temperature range of 1·3°K to 3·2°K. The experimental data are represented by an empirical equation to probable errors of 0·1% for the liquid phase and of 1·3% for the vapour phase. A.

536.48 : 535.417

898. Multiple beam investigation of liquid helium in narrow gaps. N. G. McCrum. *Phil. Mag.*, **45**, 1302–11 (*Dec.*, 1954).

A multiple-beam interferometer used for detecting liquid helium in thin gaps is described. Experiments performed with this apparatus have led to the conclusion that helium II will enter a narrow gap maintained above the liquid surface, providing the gap is bridged at a point below the surface tension height. A plausible mechanism is proposed and the bearing of the conclusions on experiments with liquid helium II discussed. A.

536.48

899. A method of concentrating He^3–He^4 mixtures. K. R. Atkins and D. R. Lovejoy. *Canad. J. Phys.*, **32**, *No.* 11, 702–7 (*Nov.*, 1954).

This method of increasing the concentration of He^3 in He^3–He^4 mixtures by "superfluid filtration," is based on the fact that liquid He^4 flows rapidly through a small leak while the He^3 in solution remains behind. In this way an increase in concentration from 2% to 95% can be achieved in a single operation. The rate of processing is about 200 standard cm^3 of the initial gaseous mixture per hour. A.

536.483

900. Installation for adiabatic demagnetization experiments at the National Bureau of Standards. D. de Klerk and R. P. Hudson. *J. Res. Nat. Bur. Stand.*, **53**, *No.* 3, 173–84 (*Sept.*, 1954).

A description is given of the National Bureau of Standards equipment for the production and measurement of very low temperatures by the method of adiabatic demagnetization. The construction of the cryostat and that of the mutual-inductance bridge are described in detail and the relative advantages of iron-cored electromagnets and iron-free solenoids are discussed. A.

536.483

901. The design and operation of a magnetic refrigerator for maintaining temperatures below 1°K. C. V. Heer, C. B. Barnes and J. G. Daunt. *Rev. sci. Instrum.*, **25**, *No.* 11, 1088–98 (*Nov.*, 1954).

The problems involved in the construction of a magnetic refrigerator operating below 1°K, using superconducting metallic links for the thermal valves and a paramagnetic salt as the working substance, are discussed. A cycle for the operation of the refrigerator is suggested and then examined for the optimum operating conditions with readily available laboratory facilities. Design equations are obtained and compared with an experimental model. The constructional details of a completely automatic experimental model of the magnetic refrigerator using lead for the thermal valves, iron ammonium alum as the working substance, a helium bath at 1°K as the high temperature reservoir, a maximum magnetic field of 7000 gauss, a 2-minute cycle of operation, and capable of extracting 120 ergs/second from a reservoir at 0·3°K are presented in full. Temperatures as low as 0·2°K are obtained with this model. Improvements in this design, its use either for the production of an isothermal reservoir or as a heat sink for adiabatic demagnetization work below 1°K, and the extension to a two-engine refrigerator for the production of a reservoir at temperatures as low as 0·05°K are also discussed. A.

536.5 : 537.371

Importance of thermal equilibrium in measurements on powdered insulators in vacuo. *See Abstr.* 972

536.531 : 621.316.89 : 621.317.79

902. A method for constructing direct reading thermistor thermometers. J. A. McLean. *J. sci. Instrum.*, **31**, *No.* 12, 455–7 (*Dec.*, 1954).

Wide manufacturing tolerance limits on the characteristics of thermistors complicate either the construction or operation of thermometers employing these elements. These difficulties may be largely overcome by a special method of construction for thermistor thermometers working between 0 and 50°C. A thermometer intended for measuring skin temperatures is described. It has a linear calibration, is direct-reading, robust and thermistors can be easily interchanged in the event of breakage. Two ranges, each of 10°C, provide a total coverage from 25 to 45°C with an accuracy of ± 0·1 deg C. A.

536.532 : 536.48

903. Thermocouples suitable for use at low temperature. W. B. Pearson. *J. sci. Instrum.*, **31**, *No.* 12, 444 (*Dec.*, 1954).

See Abstr. 414 (1954). Further information is given on the preparation of thermocouples for use below 30°K. Very dilute copper alloys with a variety of solutes have a relatively large and fairly constant absolute thermoelectric power which may be used with advantage. A.

536.587

904. Temperature control of a large water bath using a resistance thermometer. W. P. Hutchinson, E. W. Pulsford and A. G. White. *J. sci. Instrum.*, **31**, *No.* 11, 420–4 (*Nov.*, 1954).

The precautions necessary to obtain precise control of the temperature of a large water bath, using a resistance thermometer as the control element, are discussed. Details of the design and construction of a satisfactory installation are given and its performance is examined. A method of assessing the performance of any control circuit is suggested. A.

536.621

905. The construction and calibration of a Bunsen ice-calorimeter. L. E. Leake and E. T. Turkdogan. *J. sci. Instrum.*, **31**, *No.* 12, 447–9 (*Dec.*, 1954).

A calorimeter for measurement of heat content at high temperatures has been constructed and calibrated. The calibration factor is found to be 270·49 ± 0·17 international joule/g of mercury. A.

536.621 : 536.653

906. Heats of mixing. D. S. Adcock and M. L. McGlashan. *Proc. Roy. Soc. A*, **226**, 266–82 (*Nov.* 9, 1954).

A new calorimeter, suitable for the measurement of heats of mixing as small as 0·1 J resulting from the

mixing of not more than 1 cm³ of each component in the absence of any vapour phase and over a wide range of temperatures, is described. It has been used to measure heats of mixing for the pairs of liquids carbon tetrachloride + chloroform, carbon tetrachloride + *cyclo*hexane, and benzene + solutions of biphenyl in benzene. The results are examined in the light of current theories of solutions. A.

536.631

907. Atomic heat of bismuth between 1° and 4°K. P. H. KEESOM AND N. PEARLMAN. *Phys. Rev.*, **96**, *No.* 4, 897–902 (*Nov.* 15, 1954).

Between 0·96 and 2·3°K the atomic heat of a polycrystalline ingot of bismuth (99·99%) can be represented by: $c = (1{\cdot}213 \pm 0{\cdot}006)T^3 + (0{\cdot}078 \pm 0{\cdot}03)T$ millijoules/mole deg. The lattice contribution, given by the cubic term, corresponds to 117°K for the low-temperature Debye θ. Between 2·3 and 4·2°K θ decreases to 105°K. The electronic contribution is much smaller than for normal metals. A.

536.632 : 536.48

908. The specific heat of liquid helium II as a function of pressure. G. R. HERCUS AND J. WILKS. *Phil. Mag.*, **45**, 1163–72 (*Nov.*, 1954).

The specific heat of liquid helium has been measured at several densities over the temperature range 1° to 2°K. The values obtained under the saturated vapour pressure are about 10% higher than those observed by earlier workers; the results are briefly discussed. A.

536.654 : 535.338.4

909. A thermodynamic and spectroscopic study of gaseous magnesium oxide. L. BREWER AND R. F. PORTER. *J. chem. Phys.*, **22**, *No.* 11, 1867–77 (*Nov.*, 1954).

Vapour pressure measurements on solid magnesium oxide show that the solid vaporizes mainly into molecular species. Spectroscopic experiments have been conducted and have shown that the known gaseous $^1\Sigma$ electronic state of MgO is not the principal vaporizing species. A study of the ultraviolet bands, produced originally by magnesium burning in air, proves the lower electronic level of the molecule involved in this transition is more important than the $^1\Sigma$ state of MgO. Within experimental uncertainty the heat of sublimation obtained from vapour pressure measurements agrees with a spectroscopically determined heat of sublimation of the molecule involved in the ultraviolet transition. The ultraviolet bands are shown to originate from a gaseous monomer of MgO. The vapour pressure of MgO at 2200°K is $3{\cdot}8 \times 10^{-4}$ atm. and the vapour pressure over MgO reaches 1 atm. at 3040 ± 60°K. The D_0 value for MgO gas is 4·7 eV. A.

THERMODYNAMICS 536.7/.8

536.7

910. Thermodynamics of irreversible processes and generalizations of Onsager's relations. S. R. DE GROOT. *Nuovo Cimento Suppl.*, **12**, *No.* 1, 5–16 (1954) In Italian.

The two fundamental concepts of the thermodynamics, namely the production of entropy and Onsager's relations, are briefly recapitulated and applied as an example to one-dimensional conduction of heat and then to the three-dimensional conduction of heat in an anisotropic crystal. The difficulty pointed by Casimir [Abstr. 2482 (1946)] is discussed and two methods for the removal of the difficulty are described. S. WEINTROUB

536.7

911. Derivations of Onsager's reciprocal relations. E. P. WIGNER. *J. chem. Phys.*, **22**, *No.* 11, 1912–15 (*Nov.*, 1954).

Two derivations of Onsager's reciprocal relations are presented in simplified form, and the range of their validity is discussed. A.

536.7 : 530.145.6

912. Note on the quantum theory of irreversible processes. U. FANO. *Phys. Rev.*, **96**, *No.* 4, 869–73 (*Nov.* 15, 1954).

Perturbation treatments of irreversible processes are shown to rest on the assumption that the rate of dissipation of disturbances in a system exceeds their rate of input from an external source. This hypothesis is implicit in the concept of a dissipative system and is formulated mathematically in terms of the relaxation time of quantum-mechanical correlation functions or in terms of equivalent properties of the matrices that represent interaction operators in the energy scheme. A.

536.7 : 530.162

Quantum statistics of irreversible processes. *See Abstr.* 764

536.7 : 536.153.4

Thermodynamics of the Thomas–Fermi atom at low temperature. *See Abstr.* 1127

536.7 : 538.114

Thermodynamic properties of antiferromagnets. *See Abstr.* 1045

536.7 : 539.155.2

913. Isotopic effects and thermodynamic properties in the condensed phase. III. I. PRIGOGINE, R. BINGEN AND A. BELLEMANS. *Physica*, **20**, *No.* 9, 633–54 (*Sept.*, 1954) In French.

For Pt II see Abstr. 11019 (1954). The basic assumption of this paper is introduced in the following form: the free energy of an isotopic mixture is, for given values of volume per particle and temperature, the sum of the free energy of the pure isotopes and of a term due to the entropy of mixing. This assumption is shown to constitute a satisfactory method of approach for the understanding of the thermodynamic properties of isotopic mixtures. From this hypothesis the free energy of mixing, the excess volume and the heat of mixing can be expressed in terms of properties of the pure isotopes only. Striking agreement is reached with the experimental material published up to date on thermodynamic properties of isotopic mixtures (H_2–D_2, H_2–HD, T_2–D_2, He^3–He^4). The present lack of sufficient experimental data prevents the testing of many of the predictions of the model. This theory predicts for isotopic mixtures heat absorption and positive deviations from Raoult's law (positive excess free energy and thus phase separation at sufficiently low temperature). By contrast the sign of the excess volume is more complex: dilatation on mixing is

found for cases like H_2–D_2, H_2–HD or D_2–T_2, but contraction on mixing for He^3–He^4. The method does not, however, take account of the influence of quantum statistics and does not permit the study of phenomena such as the effect of the concentration of He^3 on the λ point of He^4. The treatment of such effects requires a generalization of the additivity hypothesis and will be treated separately. A.

536.75 : 535.23

914. Entropy of radiation. P. Rosen. *Phys. Rev.*, **96**, *No.* 3, 555 (*Nov.* 1, 1954).

An expression for the entropy flux of linearly polarized electromagnetic radiation of any specific intensity, K_ν, is obtained. The latter expression is then generalized to include radiation of any type of polarization. A.

536.791 : 530.162

915. A restricted quantum statistical proof of the third law of thermodynamics. P. T. Landsberg. *Phil. Mag.*, **45**, 1129–35 (*Nov.*, 1954).

The restriction resides in the fact that the proof applies only in the limit of an infinitely large system (the "limit L"). An additional restriction is that it applies only to non-interacting and structureless quantum mechanical particles whose quantum states satisfy certain requirements (the "class O" of systems). The essence of the proof depends on showing that the free energy of the system, as averaged over a grand canonical ensemble and expressed per unit volume of the system, is of the form $a - bT^d (b > 0, d > 1)$ near the absolute zero. A.

ELECTRICITY 537

537.12 : 530.145

Introduction of a fundamental length in the classical theory of the electron. *See Abstr.* 732

ELECTROSTATICS . DIELECTRICS 537.2

537.212

916. The two-dimensional electric field of a curved-sided wall or groove on an infinite plane. N. H. Langton and N. Davy. *Brit. J. appl. Phys.*, **5**, *No.* 11, 405–10 (*Nov.*, 1954).

The electric or magnetic field of a two-dimensional system consisting of a curved-sided wall or groove on an infinite plane is investigated theoretically using conformal transformations and elliptic integrals. Graphs and tables showing the variation of field intensity are given, and tables of the elliptic integrals K, E, K' and E' for complex modulus k, where $k^2 = 1 + \exp(ix)$ are appended. A.

537.212 : 538.122

917. The two-dimensional magnetic or electric field of a single isolated pole-piece. N. H. Langton and N. Davy. *Brit. J. appl. Phys.*, **5**, *No.* 12, 431–5 (*Dec.*, 1954).

The field of a single isolated pole-piece consisting of a thick parallel plate terminated by a concave semicircular cylinder is investigated theoretically. The method involves the use of conformal transformations and elliptic functions. The variation of the field strength along the edge of the pole-piece and along the external axis of symmetry is calculated and shown graphically. A.

537.22 : 621.317.722

918. The characteristics of a quartz-fibre electroscope. F. Harlen. *J. sci. Instrum.*, **31**, *No.* 11, 424–9 (*Nov.*, 1954).

The deflecting element of the electroscope is a conducting fibre mounted parallel to a support rod and kept taut by a quartz-fibre loop. A theory is developed which describes the mechanical restoring forces acting on a deflected fibre and shows how manufacturing tolerances may be accommodated so that all electroscopes conform to a given non-linear calibration curve. Experimental fibre deflection curves are discussed and a description is given of work on the conducting coating of the fibre. It is shown that the problem of ensuring continuity is essentially a matter of gilding technique. A.

537.226.1.08

919. The computation of the complex dielectric constant from microwave impedance measurements. J. P. Poley. *Appl. sci. Res. B*, **4**, *No.* 3, 173–6 (1954).

A number of diagrams is presented for deducing the value of the complex dielectric constant in an exact and straightforward way. A.

537.226.1.08 : 621.317.73

920. Dielectric test cell for bituminous material. C. Q. Keiller. *J. sci. Instrum.*, **31**, *No.* 12, 465–6 (*Dec.*, 1954).

A test cell is described which can be used in the measurement of permittivity and power factor of hard bituminous and other dielectrics which can be melted but are virtually unmachinable. These materials always contract on cooling. The cell was designed for power frequencies, but would probably be equally suitable for r.f. A.

537.226.2

921. Thermodynamic theory of anti-ferroelectrics. G. A. Smolenskiĭ and V. Kh. Kozlovskiĭ. *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 684–95 (1954) In Russian.

In ferroelectric crystals of perovskite type the central ions in the oxygen octahedrals are shifted within the domains in a single direction. However, the possibility exists of a spontaneous distribution of the ions in certain crystals so that the central ions in adjacent rows may move in an antiparallel sense. In such a single-domain crystal the total spontaneous polarization is zero, this being described as an anti-ferroelectric crystal. Previous attempts yielded a thermodynamical theory of antiferroelectrics, based on Landau's theory of metamagnetics, but dealt only with the one-dimensional case without considering anisotropy and deformations, and only with the phase transition from the antiferromagnetic state into the a-ferromagnetic state. The present paper considers transitions from the antiferroelectric into the ferroelectric state as well as from antiferroelectric into the a-ferroelectric (para-electric) state, the latter considering anisotropy and deformations. The possible cases are treated in the absence and presence

of external electric fields. The most important relations for dielectric constant, polarization, hysteresis loops, etc., with all their anomalies are calculated and the graphs representing the physical phenomena are discussed. B. F. KRAUS

537.226.2

922. Dielectric properties and phase transitions of $NaNbO_3$ and $(Na,K)NbO_3$. G. SHIRANE, R. NEWNHAM AND R. PEPINSKY. *Phys. Rev.*, **96**, *No.* 3, 581–8 (*Nov.* 1, 1954).

An optical, dielectric and structural study has been carried out on $NaNbO_3$ and the solid solution $(Na, K)NbO_3$, both single crystals and ceramics being used. No evidence for ferroelectricity in $NaNbO_3$ was found, and the crystal seems to be antiferroelectric in accordance with the nonpolar structure reported by Vousden. It is shown that a small addition of $KNbO_3$ to pure $NaNbO_3$ produces a new ferroelectric phase, the existence of which suggests a possible explanation of the conflicting dielectric and structural properties previously reported. The phase diagram of $NaNbO_3$–$KNbO_3$ is given. This, together with the optical and X-ray studies of pure $NaNbO_3$, shows that the three phase transitions in $NaNbO_3$ are quite different in nature from the $BaTiO_3$-type transitions in $KNbO_3$. A.

537.226.2

923. Nonlinearity of the polarization of ferroelectric titanates in weak fields above the Curie point. A. PIEKARA. *Bull. Acad. Polon. Sci. Cl.* 3, **2**, *No.* 3, 127–31 (1954).

Experimentally discovered proportionality of decrement of permittivity v. square of magnitude of applied weak electric field (up to 4 kV/cm) can be explained by anisotropy of the titanium ion lattice polarizability. The Mason–Matthias theory disregards the anisotropy of the atomic polarizability of titanium ions, which consists of the elastic displacement of titanium ions against the lattice under the influence of an electric field. This ion-lattice polarizability is a property of the ion lattice bond and not of the ion only. With anisotropic polarizability a measurement of α along one of the crystallographic axes gives a lower value when the titanium ion occupies one of the potential wells along the direction of the measuring field, and a higher value when the ion occupies one of the wells lying in a plane perpendicular to the direction of the measuring field. J. LUKASZEWICZ

537.226.32

924. Electret. C. YAMANAKA. Note in *J. Phys. Soc. Japan*, **9**, *No.* 3, 425 (*May–June*, 1954).

The behaviour of carnauba wax electrets depends on the amplitude of the "forming" voltage.

J. H. MASON

537.226.33

925. Dielectric hysteresis in $BaTiO_3$ monocrystals. N. S. NOVOSIL'TSEV AND A. L. KHODAKOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 1(7) 94–6 (1954) In Russian.

Oscillograms of hysteresis loops were made on $BaTiO_3$ crystals in strong fields nearing the breakdown value and a tendency of the characteristic phase transition to disappear in this range was observed. From the oscillograms it was possible to calculate values of the polarization and dielectric constant. The crystals represented two batches, the Curie points of which were 80° and 60° respectively. These crystals show a dispersion of the dielectric constant in the frequency range 10^5–10^8 c/s and a corresponding increase of dielectric losses. Two series of hysteresis loops were taken for the first batch of crystals, viz. at gradients of 9·1 kV/cm and 22 kV/cm respectively. The latter is close to breakdown stress. The dielectric constant at 50 c/s was 1960, at 10^6 c/s 1800. At temperatures above 120°c phenomena of h.v. polarization and unilateral conductivity were observed (asymmetrical loops). High field strengths smooth the curve of the temperature relation of the dielectric constant, reduce the maximum of the dielectric constant at the Curie point and increase the constant in the ferroelectric range far from the Curie point.

B. F. KRAUS

537.226.33

926. Transitory régime in dielectrics. J. GRANIER AND P. CAILLON. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 17, 1025–7 (*Oct.* 27, 1954) In French.

A discussion of the hysteresis effects which occur when simultaneous a.c. and d.c. fields are applied to a dielectric. Two independent hysteresis phenomena may be observed, one due to dipole orientation and the other to ionic polarization. C. A. HOGARTH

537.226.8

927. Temperature relation of the dielectric constant of a NaCl crystal. M. S. CHMUTIN. *Zh. éksper. teor. Fiz.*, **26**, *No.* 5, 640–4 (1954) In Russian.

The temperature relation of the dielectric constant of a NaCl crystal was investigated in the temperature range 15–550°c. It was found that between 500 and 520°c ε begins to rise considerably and that its temperature coefficient also increases suddenly. This effect cannot be explained merely on the usual theory of the temperature coefficient of the diel. const., based on lattice constants determined by elastic bond coefficient and linear expansion coefficient, but rather by the fact that the energy of the ions rises with the temperature and approaches continuously the height of the local potential barrier, this increasing the number of "weakly bound" ions, and to an increase of the polarization by weakly bound chlorine ions. At $t < 400$°c the current carriers are exclusively Na ions, whereas at $t = 600$° the Cl ions also participate in current transport. The available analytical and numerical relations confirm the increase of the diel. const. theoretically. At a lower frequency the increase of the diel. const. begins earlier, since with increasing oscillation period the polarization is slower, but more complete, and may develop at a lower temperature. The frequency relation at high temperatures would have to be investigated more closely to arrive at conclusive results. B. F. KRAUS

537.226.8

928. Statistical mechanical derivation of Onsager's equation for dielectric polarization. F. E. HARRIS AND B. J. ALDER. *J. chem. Phys.*, **22**, *No.* 11, 1806–8 (*Nov.*, 1954).

The assumptions necessary in deriving the equation for the dielectric polarization in the absence of short-range interactions between the molecules, as represented by the Onsager equation, are made explicit.

The equation derived by Harris and Alder for the general case of dielectric polarization of polar liquids is seen to involve an approximation not previously stated. The latter equation, when reduced to the limit represented by the Onsager equation, becomes identical with it when a further simplification is introduced. A.

537.226.8

929. Dielectric polarization in polar substances. Remark on a paper by F. E. Harris and B. J. Alder. H. FRÖHLICH. *J. chem. Phys.*, **22**, *No.* 11, 1804–6 (*Nov.*, 1954).

A correction of a formula for the static dielectric constant derived by Harris and Alder (preceding abstract) is given in this paper. A.

537.228.1

930. Effect of acoustic impedance and viscosity of gases on the electrical constants of quartz. S. PARTHASARATHY AND V. NARASIMHAN. *Ann. Phys.* [*Leipzig*] **15**, *No.* 1, 6–14 (1954).

The equivalent resistance, capacitance and the *Q*-factor of a quartz crystal vibrating at its fundamental frequency in several gaseous media were measured and the results compared with the acoustic impedance (*PC*) of the media. While the resistance varies linearly with *PC* the reciprocal capacitance does not. The *Q*-factor seems to vary linearly with viscosity within the small range of viscosities investigated. A.

ELECTRIC CONDUCTION . CURRENTS 537.3

537.31

931. On fluctuations in a generator with nonlinear inertia properties. M. E. ZHABOTINSKIĬ. Letter in *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 758–9 (1954) In Russian.

A discussion of the influence of random excitations on an oscillating system in which the stationary amplitudes are determined by the nonlinear inertia. The quantity *A* characterizing the stability of the maximum cycle differs from that of earlier publications. In the present case, the function equivalent to *A* which determines the intensity of amplitude fluctuations of the generator can be increased considerably. This is achieved by choosing the inertia nonlinearity suitably, which at the same time reduces the amplitude fluctuations. J. JACOBS

537.311.31

932. Electric conduction of metals taking account of the electron interaction. (Case of a Bose spectrum.) S. V. VONSOVSKIĬ AND B. V. PADUCHEV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 5(11) 571–83 (1953) In Russian.

An investigation complementary to Abstr. 5780 (1952). The same model is used in which the energy of a system of interacting electrons has the form of the sum of "elementary excitations" associated with fluctuations in the charge density, or "quasi-particles" obeying Bose statistics. The case treated now is that in which the density of the bosons is large rather than small. Using the formalism of 2nd quantization and expanding in powers of the deviations from the maximum possible boson density, one obtains a conductivity again proportional to the 1st or 2nd power of the absolute temperature T. This behaviour is thus taken to be characteristic of a boson spectrum in contrast to the T^5 law for fermions; metals with a T^3 or T^4 dependence presumably exhibit a mixture of the two. The study of the T-dependence of other properties would help to confirm this classification.

W. J. SWIATECKI

537.311.31

933. Some electrical properties of AlSb. W. SASAKI, N. SAKAMOTO AND M. KUNO. Note in *J. Phys. Soc. Japan*, **9**, *No.* 4, 650 (*July–Aug.*, 1954).

Hall and conductivity measurements on small crystals of zone-refined AlSb. From the calculated and measured values of thermoelectric power the effective mass of the free electrons (×statistical weight factor) is $(1{\cdot}8 \pm 0{\cdot}8)$ m. C. A. HOGARTH

537.311.32

934. Electrical conductivity of single crystals of graphite along the basal plane and a new and simple method of measuring electrical conductivities. A. K. DUTTA AND A. CHOWDHURY. *Indian J. Phys.*, **28**, *No.* 7, 312–18 (*July*, 1954).

The electrical conductivity of single crystals of graphite for currents along the basal plane, shows a gradual increase with decrease of thickness. This has been shown to be due to the fact that owing to the large electrical anisotropy, the current distribution is not uniform throughout the entire thickness and in consequence all methods involving the question of actual electrical contacts will not give the proper value of the conductivity. The present paper gives the details of a very simple method of measuring the electrical conductivity of specimens in the form of thin plates, in which the question of electrical contacts have altogether been eliminated. The method depends upon the observation of the damping produced due to eddy currents generated in the specimen when oscillating in a uniform magnetic field. Finally, it has been shown that the conductivities obtained from crystals of different thicknesses remain practically the same. A.

537.311.33

935. Theory of formation of the "valve" e.m.f. in semiconductors. A. I. GUBANOV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 3(9) 307–12 (1953) In Russian.

Lashkarev [Abstr. 4786 (1949)] gave the name of valve e.m.f. to an e.m.f. which is generated in a semiconductor when light or another agent produces excess electrons in the top layer and excess holes in the filled layer and when an electric field is present near the contact surface. The author calculates this e.m.f. in a hole-type semiconductor when the incidence of electrons into the conductivity zone (ionization intensity) is an arbitrary function of the distance from the electrode. F. LACHMAN

537.311.33

936. On the theory of the electric conduction of semiconductors. S. V. VONSOVSKIĬ AND V. S. GALISHEV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 5(11) 584–95 (1953) In Russian.

A study of the temperature dependence of the conductivity of semiconductors with an atomic (i.e. not ionic) crystal lattice, based on the many-electron "polar" model of a homopolar crystal with

inclusion of excited states ("excitons") according to S. P. Shubin and S. V. Vonsovskiĭ (1935–6). Using the formalism of 2nd quantization it is shown that if the conductivity of semiconductors is essentially due to the excited electronic states, its temperature dependence has the usual form $\sigma = \sigma_0 \exp(-\Delta E/kT)$, where ΔE is a quantity determined by the sum of the energy of the electron excitation and the width of the "exciton" conduction zone. This can be regarded as a justification of the result of the one-electron theory of semiconductors. W. J. SWIATECKI

537.311.33

937. The diffusion and the drift of photoelectrons in partially illuminated semiconductors. A. I. GUBANOV. *Zh. tekh. Fiz.*, **24**, *No.* 5, 933–40 (1954) In Russian.

A theoretical paper discusses equations for the diffusion and drift of photoelectrons at the boundary of the shadow in a partially illuminated crystal for carriers of one type and the external field perpendicular to the boundary, for both small and large photoconductivity. Calculations are made of the distribution of electrons and the voltage current characteristic when the illumination is near one of the electrodes and also when it is in the middle of the specimen. W. BARDSLEY

537.311.33 : 536.2.01

Theory of transport equation in strong electric field. *See Abstr.* 887–8

537.311.33 : 621.314.7 : 413 : 389.6 : 621.315.59

938. IRE standards on electron devices: definitions of semiconductor terms, 1954. *Proc. Inst. Radio Engrs*, **42**, *No.* 10, 1505–8 (*Oct.*, 1954).

A set of definitions covering solid-state phenomena, semiconductor devices including transistors.

537.311.33

939. Absorption and conductivity measurements on CdS in the soft X-ray region. E. SCHNÜRER. *Ann. Phys.* [*Leipzig*] **15**, *No.* 1, 15–20 (1954) In German.

Measurements of absorption for Cd–*K* and Cd–*L* radiation using a CdS cell as detector. The edge lies at 0·46 Å. The variation of log photocurrent with log X-ray intensity consists of one or more exponentials. There is a sharp rise in photocurrent with wavelength over the measured range 6·2 to 2 Å. C. A. HOGARTH

537.311.33

940. Semiconducting cadmium telluride. D. A. JENNY AND R. H. BUBE. *Phys. Rev.*, **96**, *No.* 5, 1190–1 (*Dec.* 1, 1954).

Both *n*-type and *p*-type conductivity can be obtained in cadmium telluride. The intrinsic band gap of cadmium telluride is 1·45 eV. Electron and hole mobilities are at least 30 cm²/V sec. The activation energies of *p*-type impurities are much larger than those of *n*-type impurities in cadmium telluride, indicating an explanation for the failure to find *p*-type conductivity in cadmium sulphide or selenide. A.

537.311.33 : 669.783 : 621.314.63

941. A mechanism for water induced excess reverse dark current on grown germanium *N-P* junctions. J. T. LAW. *Proc. Inst. Radio Engrs*, **42**, *No.* 9, 1367–70 (*Sept.*, 1954).

An ionic conduction process in the multilayers of water adsorbed on a Ge *n-p* junction bar is proposed to explain the increase in reverse dark current observed when the relative humidity to which the unit is exposed is increased. Experimental evidence supporting this postulate is given and discussed. A.

537.311.33 : 669.783 : 621.314.63

942. Surface conduction channel phenomena in germanium. H. CHRISTENSEN. *Proc. Inst. Radio Engrs*, **42**, *No.* 9, 1371–6 (*Sept.*, 1954).

Surface conduction channels on both the *n*-type and the *p*-type region of a *p-n* junction of Ge have been produced and investigated. Channels on the *n*-type region were produced by an oxygen-rich surface environment and those on the *p*-side were produced by high humidity. At an intermediate, 75% relative humidity, a condition of high surface leakage and no channel was found. A model, based on bending of energy levels at the surface to produce opposite type majority carrier conductivity than is found for the body of the Ge is used to explain the results. The particular channels studied simulate trouble conditions in transistor fabrication and in reliability problems and provide a good linkage for explanation of anomalous effects that are frequently found. A.

537.311.33

943. Properties of germanium doped with iron. I. Electrical conductivity. W. W. TYLER AND H. H. WOODBURY. *Phys. Rev.*, **96**, *No.* 4, 874–82 (*Nov.* 15, 1954).

Measurements of the temperature dependence of electrical resistivity in *p*- and *n*-type iron-doped germanium crystals indicate that Fe introduces impurity levels in Ge at $0{\cdot}34 \pm 0{\cdot}02$ eV from the valence band and $0{\cdot}27 \pm 0{\cdot}02$ eV from the conduction band. Such samples show very high resistivity at 77°K. At this temperature, *n*-type samples also show high photosensitivity and slow photoresponse, presumably because of hole traps. A.

537.311.33

944. Properties of germanium doped with iron. II. Photoconductivity. R. NEWMAN AND W. W. TYLER. *Phys. Rev.*, **96**, *No.* 4, 882–6 (*Nov.* 15, 1954).

Photoconductivity in *n*- and *p*-type Fe-doped Ge was measured at 77°K. The impurity photoconduction in both types has approximately the same spectral dependence, indicating ionization energies of about 0·3 eV. The intrinsic photoconductive response measured at 0·83 eV was found to be a function of sample composition, the photosensitivity increasing as the samples became more *n*-type. Intrinsic photosensitivity and the time of response seem linearly related. For *n*-type samples of highest sensitivity the minimum detectable radiation level at 0·83 eV was estimated to be 2×10^{-13} watts. In such samples quenching effects were found in the spectral region from 0·3 eV to 0·7 eV. Experimental results are discussed in terms of a model in which the impurity centre is capable of accepting two excess electrons. A.

537.311.33 : 535.343–15

945. Optical studies of injected carriers. III. Infrared absorption in germanium at low temperatures. R. NEWMAN. *Phys. Rev.*, **96**, *No.* 5, 1180–90 (*Dec.* 1, 1954).

For Pt II, see Abstr. 454 (1954). The absorption spectra of carriers injected into germanium at 302°K, 201°K and 82°K are given. For clean material these

spectra are qualitatively identical with the absorption spectra of free holes at the same temperatures. In some samples studied anomalous spectra were observed. Anomalous spectra were in general observed in samples containing Fe. The anomalies are tentatively identified with trapping effects. A.

537.311.33

946. Resistivity and Hall effect of germanium at low temperatures. C. S. HUNG AND J. R. GLIESSMAN. *Phys. Rev.*, **96**, *No.* 5, 1226–36 (*Dec.* 1, 1954).

An experimental investigation from room temperature down to the liquid helium temperature range is reported. Germanium samples with different kinds of impurity and different concentrations were used. At higher temperatures, satisfactory agreement between theory and experiment was found. The activation energy of the impurity states was found to be of the order of 10 mV. The scattering of the carriers in the conduction and filled bands consists mainly of lattice scattering and ionized impurity scattering. At low temperatures, however, anomalies in the Hall curves were observed. The Hall curve for every sample measured went through a maximum as the temperature was lowered. At the same time the resistivity approached a saturation value. The Hall curve of low resistivity samples finally became flat at very low temperatures. These anomalies are explained on the assumption of small but finite mobility of carriers in the impurity states. This conduction in the impurity states assumes importance at low temperatures when the concentration of carriers in the conduction band becomes very low. When this simultaneous conduction in the conduction band and the impurity band is considered, the behaviours in the Hall and the resistivity curves are satisfactorily explained. The mobility in the impurity band is found to increase with the impurity concentration, but is rather temperature-independent. A.

537.311.33

947. Electrical and optical properties of intermetallic compounds. I. Indium antimonide. R. G. BRECKENRIDGE, R. F. BLUNT, W. R. HOSLER, H. P. R. FREDERIKSE, J. H. BECKER AND W. OSHINSKY. *Phys. Rev.*, **96**, *No.* 3, 571–5 (*Nov.* 1, 1954).

The conductivity and Hall coefficient of InSb have been measured over the temperature range 78°K to 750°K. At low temperatures an electron mobility of 30 000 cm²/volt-sec and a mobility ratio of 29 are observed. The effective mass of electrons is $0{\cdot}04m$ and the width of the forbidden energy gap is 0·23 eV at $T = 0$°K. Optical absorption studies have been made at temperatures between 13°K and 300°K. The position of the absorption edge of degenerate *n*-type samples depends on the impurity content and is in good agreement with Burstein's predictions. A.

537.311.33

948. Electrical and optical properties of intermetallic compounds. II. Gallium antimonide. R. F. BLUNT, W. R. HOSLER AND H. P. R. FREDERIKSE. *Phys. Rev.*, **96**, *No.* 3, 576–7 (*Nov.* 1, 1954).

The Hall effect and resistivity of GaSb have been investigated over the temperature range 78° to 750°K. Hole mobilities as high as 400 cm²/volt-sec and a forbidden energy gap of 0·775 eV at absolute zero were found. Optical absorption studies at temperatures between 10°K and 300°K confirm this value of the band separation. A.

537.311.33

949. Electrical and optical properties of intermetallic compounds. III. Aluminum antimonide. R. F. BLUNT, H. P. R. FREDERIKSE, J. H. BECKER AND W. R. HOSLER. *Phys. Rev.*, **96**, *No.* 3, 578–80 (*Nov.* 1, 1954).

Measurements of resistivity, Hall coefficient, and optical absorption of AlSb are reported. The width of the forbidden energy band, derived from electrical and optical data, is 1·6 eV at absolute zero. Absorption bands are observed at 0·75 eV in *p*-type samples and at 0·31 eV in tellurium-doped *n*-type specimens. An energy level diagram with several acceptor and donor levels in the forbidden energy band is suggested to explain these observations. A.

537.311.33

950. Some electrical properties of natural crystals of iron pyrite. J. C. MARINACE. *Phys. Rev.*, **96**, *No.* 3, 593 (*Nov.* 1, 1954).

Room-temperature Hall mobilities of natural single crystals of iron pyrite with carrier concentrations of approximately 10^{18}/cm³ were found to be approximately 100 cm²/volt-sec for electrons and 1 for holes. Resistivity as a function of temperature was measured on six samples in the range from −196°C to 403°C; from this measurement the width of the forbidden band was estimated to be 1·2 eV. A.

537.311.33

951. Electrical properties and the solid-vapor equilibrium of lead sulfide. R. F. BREBRICK AND W. W. SCANLON. *Phys. Rev.*, **96**, *No.* 3, 598–602 (*Nov.* 1, 1954).

Natural PbS crystals were exposed to various pressures of sulphur-vapour near 550°C and then quenched. Calculations based on the penetration of *p–n* junctions gave an interdiffusion constant of 2×10^{-6} cm²/sec at 550°C. The temperature dependence of the Hall coefficient and resistivity for several treated crystals was determined. A forbidden energy gap of $0{\cdot}37 \pm 0{\cdot}01$ eV and an electron to hole mobility ratio of 1·4 was obtained. A.

537.311.33

952. On the question of the nonlinearity of the current–voltage characteristic of the resistance of silicon carbide. N. P. BOGORODITSKIĬ AND Z. F. VOROBEĬ. *Zh. tekh. Fiz.*, **24**, *No.* 5, 811–17 (1954) In Russian.

An experimental investigation of different powders of SiC for various degrees of compression using no bonding medium. Voltage pulses were applied to the powder and the current voltage characteristic observed on the c.r.o. The characteristics do not intersect. Results are shown graphically. The non-linearity coefficient (α) of this characteristic ($E = j\epsilon^{\alpha}$) is not a steady quantity but depends on the range of the electric field and for each grain size has a certain maximum value. For coarse grains the non-linear part in the characteristic begins at smaller fields and the advantages of choosing the smaller-size particles for higher fields is discussed. The existence of a surface layer of oxide is discounted. W. BARDSLEY

537.311.33

953. Investigation of the rectifying properties of the contact Se–HgSe. A. F. Bel'skiĭ and A. I. Blum. *Zh. tekh. Fiz.*, **24**, *No.* 5, 826–32 (1954) In Russian.

After a short review of the field presents, graphically, experimental data on the influence on the rectifying properties of the system of the preparation of the HgSe, of the crystallization of the Se, and the materials (Fe, Ni, Al, Cu, Cd, Mg) used for the electrodes. Confirms surface rectification with the forward direction for minus on the HgSe. The rectification ratio does not exceed 10. Rectification at the interface Se–HgSe is similar to that at the interface Se-metal while rectification at the interface HgSe-metal is not as great and depends less on the work function of the metal than in the case of Se-metal. Systems using very pure (99·99%) Se show a maximum coefficient of rectification at 2 V.

W. BARDSLEY

537.311.33

954. Transient phenomena in the backward direction of germanium crystal rectifiers. M. Kikuchi and Y. Tarui. Note in *J. Phys. Soc. Japan*, **9**, *No.* 4, 642–4 (*July–Aug.*, 1954).

If a pulsed voltage of sufficient magnitude is applied to a Ge diode in the reverse direction the current stays constant for a while and then suddenly increases. This step is found to occur when the contact temperature reaches a critical temperature of order 80°C.

C. A. HOGARTH

537.312.5

955. Photosensitive lead sulphide layers with new properties. T. Piwkowski. *Bull. Acad. Polon. Sci. Cl.* **3**, **1**, *No.* 5, 185–7 (1953).

Sensitizing processes are described for vacuum layers and for layers which are not impaired by the atmosphere. Properties of these layers are briefly reported. The "open" layers have an edge at $2{\cdot}5\,\mu$ and a tail band extending to $3{\cdot}5\,\mu$. C. A. HOGARTH

537.312.5

956. Some peculiarities of the movement of electrons in coloured crystals of alkali halides during photoconductivity. N. P. Kalabukhov. *Zh. éksper. teor. Fiz.*, **25**, *No.* 3(9) 322–6 (1953) In Russian.

Presents graphed results of measurements of electric conductivity of coloured NaCl and KCl crystals in a direction at right angles to that of the applied external electric field; the discharge currents have been measured. It is found that the curve showing the relationship between discharge current and external electric field has a minimum value for fields roughly equal to those for which a plateau can be observed in the photocurrent/field curve. It is suggested that, in coloured alkali-halide crystals, the photoconductivity electrons can undergo a quantum scattering from both colour centres and vacancies. The apparatus used is described and shown in diagrammatic views. The approximate value of the *F*-centre radius has been calculated from the results obtained as 2×10^{-8} cm for NaCl crystals, and $0{\cdot}78\times10^{-8}$ cm for KCl crystals.

F. LACHMAN

537.312.5

957. Photoconductivity in cadmium selenide. H. J. Dirksen and O. W. Memelink. *Appl. sci. Res. B*, **4**, *No.* 3, 205–16 (1954).

The material is supposed to be electrically homogeneous in case the photocurrent is much larger than the dark current. In order to compute the concentration of electrons in the conduction band a band model with two impurity levels was assumed. To explain the temperature- and illumination-dependence of the photocurrent it proved to be necessary to assume the recombination of electrons in the conduction band and empty states of the lowest impurity level to be of negligible order. A.

537.312.5

958. The e.m.f. arising from the illumination of lead sulphide photoresistors. R. Ya. Berlaga and L. P. Strakhov. Letter in *Zh. tekh. Fiz.*, **24**, *No.* 5, 943 (1954) In Russian.

It has been shown (Abstr. 2337 (1946)] that PbS layers can give an e.m.f. of 2 V. Prepared without the polarizing current, such layers give an e.m.f. which is about 1·4 V and whose sign and magnitude depends markedly on the conditions of illumination. Such a layer was obtained by evaporating PbS in 0·05–0·1 mm CO_2 at a temperature of 240–250°C, warming to 500°C for 5–10 min and then allowing to cool to room temperature in the vacuum plant.

W. BARDSLEY

537.312.5

959. Photoconductivity of In_2Te_3 and CdTe single crystals. H. Miyasawa and S. Sugaike. Note in *J. Phys. Soc. Japan*, **9**, *No.* 4, 648–50 (*July–Aug.*, 1954).

Values for the photoconduction threshold for In_2Te_3 and CdTe are obtained as 1·2 and 1·47 eV, respectively. G. F. J. GARLICK

537.312.6

960. Some anomalies in the behaviour of metals heated by current pulses of great density. S. V. Lebedev and S. É. Khaĭkin. *Zh. éksper. teor. Fiz.*, **26**, *No.* 5, 629–39 (1954) In Russian.

Measurements of resistance and energy with current pulses of $\sim10^7$ A/cm² density show that the metal then has anomalous characteristics. This applies above all when the resistance approaches the value obtaining at fusion of the solid metal. At a certain instant there is a sudden increase of dR/dE. This instant corresponds to a resistance $\nless$ that at the melting point, but the energy liberated simultaneously $>$ that required for heating the metal from room temperature to melting point. The excess depends on the current density used for heating the metal. The energy required for the temperature rise to melting point takes a value much higher than usual if the time required for this rise $< 5\times10^{-6}$ sec, which corresponds to the current density mentioned. Wrana, with whose conclusions the results of the authors agree, calls this energy that of complete evaporation of the metal. There is further agreement on the observable fact that this energy increases at higher current densities. There are, on the other hand, divergences in the interpretation of this increase of the energy, since the authors show that it cannot be due to an increase of the pressure around a very rapidly evaporating wire. B. F. KRAUS

537.312.62

961. Superconducting elements. J. EISENSTEIN. *Rev. mod. Phys.*, **26**, *No.* 3, 277–91 (*July*, 1954).

A critical review of the values of transition temperatures, critical fields and electronic specific heats of the superconducting elements. D. SHOENBERG

537.312.62

962. Investigation on bismuth alloys at very low temperatures. N. E. ALEKSEEVSKIĬ AND YU. P. GAĬDUKOV. Letter in *Zh. éksper. teor. Fiz.*, **25**, *No.* 3(9) 383–4 (1953) In Russian.

It was found experimentally that the intermetallic compound Bi_2Pt displays superconductivity. The $H_c(T)$ relationship is expressed by the formula $H_c/H_0 + (T/T_c)^2 = 1$, where $H_0 = 9{\cdot}5$ Oe and $T_c = 0{\cdot}155$°K, which is so far the lowest recorded superconductivity transition temperature. The BiPt alloys gave uncertain results, and the measurements must be repeated. Bi_2S_3 did not display superconductivity down to 0·1°K; Bi_4Rh displayed superconductivity only in hardened state. F. LACHMAN

537.312.62

963. The stability of superconducting regions. H. KOPPE. *Z. Naturforsch.*, **9a**, *No.* 9, 724–6 (*Sept.*, 1954) In German.

It is shown that a cylindrical superconducting region which lies entirely in the interior of a superconductor is not thermodynamically stable. H. LONDON

537.312.62

964. Structure of the intermediate state of superconductors. B. SERIN. Letter in *Phys. Rev.*, **96**, *No.* 1, 228–9 (*Oct.* 1, 1954).

The structure in Pb at 1·4°K was studied by placing thin magnetic tape in an appropriate place (between two hemispheres or at a pole of the compound sphere), applying a magnetic field of about $0{\cdot}8H_c$ normal to the diametral gap, removing the field and warming up. The tape retains a memory of the magnetic pattern of the field when it was applied and this pattern is revealed by applying ferromagnetic powder. Preliminary results show a structure of scale about 0·05 mm for a sphere of radius 6 mm. D. SHOENBERG

537.312.62

965. Effect of precipitation hardening on the superconducting transition of an aluminium alloy. R. E. MOULD AND D. E. MAPOTHER. Letter in *Phys. Rev.*, **96**, *No.* 3, 797–8 (*Nov.* 1, 1954).

The $H_c - T$ curve of Al is displaced to lower temperatures by about 0·05°K by alloying with 0·7% of Mg and 0·4% Si and precipitation hardening. In the quenched or annealed conditions the alloy shows the same $H_c - T$ curve as does a pure Al single crystal. D. SHOENBERG

537.312.62

966. New criterion for superconductivity in metals. G. GROETZINGER, D. KAHN AND P. SCHWED. *Phys. Rev.*, **96**, *No.* 4, 887–9 (*Nov.* 15, 1954).

A criterion for the occurrence of superconductivity based on the (average) freedom number f of the free electrons in the metal is proposed and applied to the nine superconductors and twelve nonsuperconductors for which the freedom number can be calculated on the basis of the available information. For all the superconductors the freedom number lies between +0·15 and −0·16 and, while it is equal to 0·14 for one nonsuperconductor, it lies outside these limits for all the other nonsuperconductors. The quantity $\gamma = (n/n_f)f$, where n_f/n is the number of free electrons per atom, can be calculated for a larger number of elements (14 superconductors and 27 nonsuperconductors) than f. A criterion based on this quantity is still fairly successful for elements with normal Hall effect and somewhat less successful for elements with anomalous Hall effect. A comparison of the proposed criteria with criteria due to Kikoin and Lasarew, Fröhlich, and Bardeen shows that the criteria based on f and γ are more successful. A.

537.312.62

967. Lifetime of positrons in superconducting lead and tin. R. STUMP AND H. E. TALLEY. *Phys. Rev.*, **96**, *No.* 4, 904–7 (*Nov.* 15, 1954).

The mean life of positrons was measured in superconducting lead and tin. Consistent results were obtained with the lead sample giving an average value for the mean life of $(0{\cdot}57 \pm 0{\cdot}07) \times 10^{-9}$ sec. A null result was obtained with tin; the measured value of the lifetime was $(0{\cdot}15 \pm 0{\cdot}09) \times 10^{-9}$ sec, as compared with the room temperature value of $0{\cdot}15 \times 10^{-9}$ sec. The data indicate that the lifetime change in lead is a superconductive phenomenon and not due simply to the low temperature of the sample. Conjectures are made to explain the different results obtained with lead and tin. A.

537.312.62

968. High-frequency resistance of tin and indium in the normal and superconducting state. C. J. GREBENKEMPER. *Phys. Rev.*, **96**, *No.* 5, 1197–8 (*Dec.* 1, 1954).

Additional measurements have been made on the surface resistance of tin and indium near 24 000 Mc/s. The results are in general agreement with those reported previously. The high-frequency resistance appears to be varying with frequency in the superconducting region as the three-halves power rather than the predicted second power. This appears to be the case for both tin and indium. The effect of evaporating a thin indium film over an electroplated film is discussed. Data for the normal state are in general agreement with the Reuter–Sondheimer theory of the anomalous skin effect. A.

537.312.62 : 534.23

969. Ultrasonic attenuation in superconducting lead. H. E. BÖMMEL. Letter in *Phys. Rev.*, **96**, *No.* 1, 220–1 (*Oct.* 1, 1954).

The attenuation in Pb of sound at frequencies from 9 to 27 Mc/s shows a marked temperature dependence between 2 and 18°K. Below T_c the curve has two branches corresponding to the superconducting and normal states (the latter achieved by applying a sufficient magnetic field). In the S-state the attenuation falls very sharply as T is decreased, while in the N-state it continues to rise till it flattens off at about 4°K. Intermediate values are obtained if a field is "frozen-in." The temperature variation is similar to that of thermal conductivity. The difference of attenuation between S and N states varies roughly as the square of the frequency. D. SHOENBERG

537.322 : 537.311.33 : 621.315.59

970. The use of semi-conductors in thermoelectric refrigeration. H. J. GOLDSMID AND R. W. DOUGLAS. *Brit. J. appl. Phys.*, **5**, *No.* 11, 386–90 (*Nov.*, 1954).

The factors governing the selection of semiconductors for thermoelectric refrigeration are discussed. It is concluded that they should be chosen with high mean atomic weights and be prepared with thermoelectric powers of 200–300 μV deg C^{-1}. Preliminary experiments have led to the production of a thermocouple of Bi_2Te_3 and Bi capable of maintaining 26 deg C of cooling. A.

537.323 : 537.311.33

971. Theory of the thermoelectric power of semiconductors. C. HERRING. *Phys. Rev.*, **96**, *No.* 5, 1163–87 (*Dec.* 1, 1954).

The usual theory of thermoelectric power fails to account for the marked rise in this quantity which has been found recently for some semiconductors as the temperature is lowered below room temperature. This paper develops the recently suggested explanation that the thermoelectric power Q is the sum of the usual electronic term Q_e, resulting from the spontaneous tendency of the charge carriers to diffuse from hot to cold, and a phonon term Q_p, resulting from the drag on the charge carriers exerted by the phonons streaming from hot to cold in thermal conduction. An equivalent description of the term Q_p can be given in terms of the contribution to the Peltier heat flux in an isothermal specimen, due to phonons dragged along by the electric current. As a prelude to the discussion of Q_p, the existing theory of Q_e is first subjected to some refinements required by recent developments in semiconductor theory. The theory of Q_p is then formulated in a simple but general way by making use of an approximate proportionality between heat current and crystal momentum in the phonon system. Using recently-derived results on the probability that a very low-frequency phonon will be scattered by other phonons, an explicit expression for $Q_p(T)$ is derived, which should be valid in the range of moderately low temperatures and low carrier concentrations. At lower temperatures, but still far above the range where the thermal conductivity is appreciably size-dependent, Q_p is dominated by the scattering of phonons from the boundaries of the specimen; the theory of this effect is worked out in detail. Although Q_p is independent of carrier concentration when the latter is low, a considerable decrease is predicted at high carrier concentrations, or at very low temperatures, because of a saturation effect. The effect of Fermi degeneracy on all these phenomena is discussed. Available data on *p* germanium show all these effects and can be fitted by the theory. The comparison indicates that a large proportion of the low-temperature lattice scattering of holes in *p* germanium is by shear modes. Although *n* germanium seems less suited for quantitative comparison, it also shows all the predicted effects. A.

537.371 : 536.5

972. Importance of thermal equilibrium in measurements on powdered insulators *in vacuo*. R. H. BUBE AND R. E. SHRADER. Letter in *Rev. sci. Instrum.*, **25**, *No.* 9, 921–2 (*Sept.*, 1954).

ELECTRIC DISCHARGES 537.52

537.521

973. Initiation of an electric discharge in gases with a.c. of acoustic frequency in vessels with external and internal electrodes. N. A. KAPTSOV AND N. A. POPOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 1(7) 97–102 (1954) In Russian.

The conditions of starting and running discharges in vessels with external and internal electrodes in their dependence on the frequency of the applied voltage were compared. In the case of external electrodes two types of discharges exist, viz. an unstable and a stable type, at small and higher voltages, respectively, and two different igniting voltages corresponding to the two types. At a frequency of 10 kc/s the igniting voltage-frequency curves of the two types become similar to each other. The unstable discharge takes the form of successive short pulses. The igniting voltage of the unstable discharge in the range 30–10 000 c/s is independent of the frequency, whereas that of the stable discharge within the same range decreases with increasing frequency in vessels with external electrodes and gradually approaches the values of the igniting voltage for vessels with internal electrodes. B. F. KRAUS

537.523.4 : 621.3.015.54

974. High current spark channels. J. E. ALLEN AND J. D. CRAGGS. *Brit. J. appl. Phys.*, **5**, *No.* 12, 446–53 (*Dec.*, 1954).

Measurements were made on high current (up to 265 kA) spark channels in air, argon and hydrogen. The voltage gradients existing in the channels were determined by oscillographic measurements and were found to increase with increasing current in the range studied. Power inputs of tens of MW per cm length of channel were derived from the measured voltage gradients. Rotating-mirror photographs of the discharges were taken, using a camera with a resolution better than $\frac{1}{4}$ μsec. The photographs obtained show a number of features which are peculiar to these high-current discharges, the chief one being the bright central core of the discharge, which was photographed in every case. Temperatures of about 10^5 °K were estimated from electron mobility considerations. The central core of the discharge appears to be due to the self-magnetic "pinch" effect, and calculations based on this inference suggest that high ion densities ($\sim 10^{19}$ per cm^3) exist in the centre of the core; the energy requirements for such conditions are compatible with the measured power inputs. A.

537.525.8 : 537.312 : 537.533.8

975. The state of affairs in gas-filled photocells in the régime of self-maintained discharges. W. KLUGE AND A. SCHULZ. *Z. angew. Phys.*, **6**, *No.* 8, 364–70 (*Aug.*, 1954) In German.

A continuation of previous work [Abstr. 1425 (1954)] on reversible secondary emission decay phenomena observed in photocells with composite cathodes (Ag–Cs_2O, Cs, Ag–Cs) in sub-normal glow discharges. It is concluded that the phenomena are identical with the well-known photoemission decay and that the sources of photoemission and secondary emission are surface adsorbed Cs atoms. A mathematical treatment is given. C. G. MORGAN

537.529 : 537.583

976. Theory of electric breakdown in the high-temperature region and its relation to thermionic emission. K. LEHOVEC. *Phys. Rev.*, **96**, *No.* 4, 921–8 (*Nov.* 15, 1954).

The decrease of von Hippel's breakdown field caused by random fluctuations of electron energy is estimated from consideration of the distribution function of electrons in strong fields. This decrease of breakdown field is appreciable at ordinary temperatures in case of the interaction of electrons with optical modes of lattice vibrations in ionic lattices and this may account for the observed decrease of breakdown field with increasing temperatures at elevated temperatures. The rate of formation of "fast" electrons from "slow" electrons is used to estimate the deviations from thermal equilibrium distribution of electrons at the surface of a thermionic cathode. Deviations from Richardson's equation are expected if $E(h\nu)/(kT)^2 \lesssim (3/16)^{\frac{1}{2}}$, where E is the height of energy barriers at the surface above the bottom of the conduction band in semiconductors, $h\nu$ is the phonon energy, and kT is the energy equivalent of temperature. A strong increase of the thermionic emission current with the field in the cathode is predicted for semiconductors at fields of the order of the breakdown field. A.

X-RAYS 537.531

537.531 : 535.33.07

977. Relation between the width of an X-ray line and the resolving power of the double-crystal spectrometer. G. BROGREN. *Phys. Rev.*, **96**, *No.* 3, 589 (*Nov.* 1, 1954).

The widths of some K_{α_1} lines were measured in a double-crystal spectrometer in the $(1, +1)$ position. It was found that the difference between the experimental width of the line and the width of the rocking curve had a constant value when perfect crystal gratings were used. A.

537.531 : 615.849.1 : 535.343

978. Spatial distribution of energy dissipation by high-energy X-rays. H. BRYSK. *Phys. Rev.*, **96**, *No.* 2, 419–25 (*Oct.* 15, 1954).

The space distribution of energy dissipated by betatron X-rays results from the combined propagation of the X-rays and of their secondary electrons. This distribution has been calculated for a 40 MeV bremsstrahlung spectrum incident on a mass of water. The calculation is described and the results are compared with related experiments. A.

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533

979. Orbital periods in the microtron. H. F. KAISER. Letter in *Rev. sci. Instrum.*, **25**, *No.* 10, 1025–6 (*Oct.*, 1954).

A general discussion is given of possible sequences of energy increments and orbital periods. J. J. WILKINS

537.533 : 621.384.62 : 621.385.833

980. Electronic-ram experiments. I. J. BILLINGTON AND W. R. RAUDORF. *Wireless Engr*, **31**, *No.* 11, 287–92 (*Nov.*, 1954).

See Abstr. 7933 (1951). A model of an electronic ram was built and operated to examine experimentally the underlying principle. The work comprised: projecting a 100 mA cylindrical electron beam of 100 cm length; controlling the axial velocity, space-charge density and cross-sectional area of the beam by a steady axially-symmetric magnetic field; the sudden stopping of the beam on entering a region of rapidly increasing magnetic-field intensity to transfer the magnetic energy associated with the whole beam to the electrons at the front of the beam. The results obtained are qualitatively in accordance with theory and indicate the existence of a "ram effect." A.

537.533.31

981. Rigorous calculation of a typical electrostatic unipotential lens. W. GLASER AND P. SCHISKE. *Optik*, **11**, *No.* 9, 423–43 (1954) In German.

The rigorous calculation of magnetic electron lenses has been carried out previously using the bell-shaped field function of Glaser. The present paper carries out the analogous calculation for the electrostatic lens. The equations of image formation are derived and the principal parameters of the lens calculated, including spherical and chromatic aberration coefficients. Applications such as electron velocity analysis and electron velocity filter are discussed.

A.E.I. RESEARCH LABORATORY

537.533.31

982. Rigorous calculation of a typical electrostatic unipotential lens (continued). W. GLASER AND P. SCHISKE. *Optik*, **11**, *No.* 10, 445–67 (1954) In German.

Continues the exact calculation reported in the preceding abstract, using an analytical field distribution. The results are shown graphically in the form of trajectories. Trajectories are also shown for the lens acting as a velocity spectrograph.

A.E.I. RESEARCH LABORATORY

537.533.331 : 621.385.833

983. Some properties of symmetrical slit ("cylindrical") electron lenses. G. D. ARCHARD. *Brit. J. appl. Phys.*, **5**, *No.* 11, 395–9 (*Nov.*, 1954).

The focal lengths of a series of symmetrical slit ("cylindrical") electrostatic electron lenses are determined as a function of aperture size and applied potential. It is shown that all practical lenses may be represented on a single curve by means of a parameter simply related to potential and geometry. It is deduced that lens strength depends more on the size of the central aperture than on that of the outer apertures. A.

537.533.35 : 537.531

984. A fine focus X-ray tube for shadow microscopy. Y. KATŌ, S. YAMANAKA AND G. SHINODA. *Technol. Rep. Osaka Univ.*, **3**, *No.* 56, 5–10 (*March*, 1953).

An electron microscope used as a fine focus X-ray tube and X-ray shadow microscope is described. It has two electromagnetic lenses and the focus of the electron beam may be reduced to 5×10^{-4} mm in

diameter. The high voltage is supplied by a series resonance circuit and stabilized by back feeding. A.

537.533.7

985. Velocity of electron pulses. L. L. WHYTE, D. L. RICHARDS AND D. GABOR. *Nature* [*London*] **174**, 398–9 (*Aug.* 28, 1954).

The transit time of a very short pulse of monokinetic electrons over a measured distance was determined. This was achieved by using two deflector gates which are opened for an interval of approximately 10^{-10} sec by a single surge travelling in a known length of delay cable between the first and second gate. By using a BeCu electron multiplier, pulses of 50 electrons were detected and the transit time determined to within $\pm 0{\cdot}25\%$. It is suggested that the apparatus could be used as a velocity spectrograph or as a chronograph for measuring the rise time of very steep surges. D. R. CHICK

537.533.74

986. Cross-section theorem. R. A. MAPLETON. *Phys. Rev.*, **96**, *No.* 2, 415–18 (*Oct.* 15, 1954).

A cross-section theorem is derived for systems consisting of several identical particles. The total cross-section for all processes; elastic, inelastic and ionization is given in terms of the imaginary part of a linear combination of direct and exchange forward amplitudes. A.

537.533.74 : 548.7

987. Scatter of high-energy electrons in crystals. M. L. TER-MIKAELYAN. *Zh. éksper. teor. Fiz.*, **25**, *No.* 3(9) 289–95 (1953) In Russian.

Analyses the scatter of relativistic electrons in periodic media, from a diatomic molecule to the simple cubic lattice. It is shown that, although the wavelength of the scattering electron is far smaller than the lattice constant (or the molecule dimension), significant corrections are introduced into the conventional scatter formulae by allowing for the interference phenomena. F. LACHMAN

537.533.8

988. The use of radioactive isotope in a study of evolution of strontium oxide under electron bombardment. S. YOSHIDA, N. SHIBATA, Y. IGARASHI AND H. ARATA. Note in *J. Phys. Soc. Japan*, **9**, *No.* 4, 640–1 (*July–Aug.*, 1954).

Sr^{89} was used to measure the rate of liberation of Sr from the oxide under bombardment currents between 1 and 3·5 mA at 150 eV. The rate increased linearly with current and exponentially with temperature between 250° and 450°C. The quantity liberated by 500 eV electrons was much less than by 150 eV electrons. C. G. MORGAN

537.533.8

989. The similarity law of secondary emission. J. L. H. JONKER. *Philips Res. Rep.*, **9**, *No.* 5, 391–402 (*Oct.*, 1954).

In literature, the curves of the secondary-emission coefficient δ measured as a function of the energy εV_p of the primary electrons often show great deviations from the experimental universal curve, i.e. do not satisfy the similarity law. It is shown that some of these deviations may be caused by the fact that the target is partly or completely covered with foreign materials. Many materials were measured again with extra precautions for having a clean surface, and tables are given for a number of materials whose measured δ-curve agreed with the experimental universal curve. In that case the indication of the values of δ and εV_p at the maximum of the $\delta = f(\varepsilon V_p)$ curve is sufficient; other values of δ can then be deduced from the experimental universal curve, for which a formula has been added. A.

537.533.8

990. Emission of energetic secondary electrons produced by 1·3-MeV electron bombardment. R. A. SHATAS, J. F. MARSHALL AND M. A. POMERANTZ. *Phys. Rev.*, **96**, *No.* 5, 1199–203 (*Dec.* 1, 1954).

The emission of energetic secondary electrons (δ-rays or knock-on electrons) produced by 1·3 MeV primaries which penetrate thin targets with negligible mean energy loss has been investigated. These have previously not been observable in the customary thick-target experiments because of the inherent impossibility of distinguishing between true secondaries and reflected primaries which have suffered large energy losses. The present arrangement does not record back-scattered primaries, but only emitted electrons. The δ-ray yields from various targets (Al, Ni, Au, Ag, Cu, C) ranging in thickness from 5×10^{-6} to 10^{-2} in. have been measured. The determinations of I_δ/I_p vary between $0{\cdot}3\%$ and $2{\cdot}1\%$ independent of surface treatment, and there is only a small dependence of the yield upon target material for an equivalent thickness expressed in $mg.cm^{-2}$. For $45{\cdot}8$ $mg.cm^{-2}$ Ni, the δ-ray yield is $2{\cdot}08 \pm 0{\cdot}15\%$. This may be compared with $1{\cdot}48 \pm 0{\cdot}25\%$, the yield of low-energy secondaries as measured with the cleanest surface attainable in the demountable experimental tube. A.

537.533.8 : 548.7

991. The interference emission of high-energy electrons. M. L. TER-MIKAELYAN. *Zh. éksper. teor. Fiz.*, **25**, *No.* 3(9) 296–306 (1953) In Russian.

See Abstr. 6548 (1950). Discusses the emission of high-energy electrons in a crystal. It is shown that the interference effects ought to be allowed for when the pulse which acts on the system along the direction of the electron-path becomes equal to a pulse corresponding to the dimensions of the unit cell. This occurs for energy values $E_0 > mc^2(a/4\pi\lambda)\varepsilon/(1-\varepsilon)$, where a = lattice constant, λ = Compton wavelength of the electron and ε = energy of the emitted quantum in terms of original energy. With energies of this magnitude the emission will be very large for certain directions of incidence with respect to the monocrystal; in other directions it will be somewhat (5–25%) less than in an analogous amorphous substance. The mean energy loss, calculated for all angles of incidence, will be the same as for the amorphous substance. A formula is developed for the bremsstrahlung of a narrow electron beam incident along one of the main axes of a cubic crystal. F. LACHMAN

537.534

992. On the phase oscillations of a strong-focusing synchrotron (an investigation using a mechanical analogue machine). E. BODENSTEDT. *Ann. Phys.* [*Leipzig*] **15**, *No.* 1, 35–54 (1954) In German.

It is possible to accelerate particles through the

"critical energy" if certain requirements are met. Tolerance requirements are shown to be technically acceptable. P. A. STURROCK

537.534

993. Amplitude of oscillation in the strong-focused synchrotron. J. SEIDEN. *C.R. Acad. Sci.* [*Paris*] **239,** *No.* 14, 798–800 (*Oct.* 4, 1954) In French.

Formulae are given relating the mean square displacement of the closed orbit from its ideal position to the misalignments of individual sectors. In this connection the effect of coupling between radial and vertical motion is small. A formula is given for the effect of such coupling on the amplitude of oscillation about the closed orbit. J. S. BELL

537.534 : 621.319.339

994. A portable Van de Graaff generator. T. R. FOORD. *J. sci. Instrum.*, **31,** *No.* 12, 440–1 (*Dec.*, 1954).

A simple and inexpensive air-insulated Van de Graaff generator is described which develops a maximum open-circuit voltage of ~200 kV and has a short-circuit current of 15 μA. A.

537.534.74

995. The scattering of nucleons by alpha particles—the *s*-phases. S. HOCHBERG, H. S. W. MASSEY AND L. H. UNDERHILL. *Proc. Phys. Soc.* [*London*] *A*, **67,** *Pt* 11, 957–66 (*Nov.*, 1954).

The *s*-phase shifts for scattering of neutrons and of protons by α-particles have been calculated over the energy range 0–4 MeV. A central interaction between nucleons of Gaussian form has been assumed, the constants being consistent with the binding energy of the deuteron and α-particle. The resonating group structure method has been employed to provide integro-differential equations for the wave-functions which describe the scattering. These equations are internally consistent in that the functions used to describe the resonating groups are only assumed to satisfy the usual variational integral condition in terms of the α-particle binding energy. The *s*-phases were determined by accurate numerical solutions of the equations. Very good agreement was obtained with the phases derived from analysis of observed data both for neutron and for proton scattering, provided the internucleonic forces were taken to be of symmetrical exchange character. The work is a necessary preliminary to an investigation of the *p*-phases in terms of an internucleonic spin-orbit interaction. A.

537.534.74

996. Proton-proton scattering at 5·77 MeV. E. J. ZIMMERMAN, R. O. KERMAN, S. SINGER, P. G. KRUGER AND W. JENTSCHKE. *Phys. Rev.*, **96,** *No.* 5, 1322–32 (*Dec.* 1, 1954).

Absolute differential scattering cross-sections for proton-proton scattering at laboratory energies of 5·77 and 5·86 MeV (±1%) have been obtained with an accuracy of ~1% at many angles (23° to 110° c.m.) by two independent experiments, one employing nuclear emulsion plates as detectors and the other employing proportional counters. Reduced to the same energy, the average indicated *S*-wave nuclear phase shift is in excellent agreement with other data for this energy region. However, at small scattering angles, important for determining a *P*-wave phase shift, the measured cross-sections differed originally by 3 to 5%, the nuclear emulsions method indicating a *P*-wave shift of $-0{\cdot}08 \pm 0{\cdot}05$ degree, and the original counter data indicating $-0{\cdot}34 \pm 0{\cdot}05$ degree. After the beam collimation was improved and the energy spectrum of the incident proton beam was examined, check runs with the counters at six scattering angles failed to indicate the large *P*-wave effect, giving $-0{\cdot}08 \pm 0{\cdot}07$ degree, in agreement with the emulsion data. It therefore appears likely that the *P*-wave shift at this energy is small (less than 0·1 degree) and negative, in agreement with other determinations in this energy region. A.

537.534.74

997. Determination of alpha-alpha scattering phase shifts. J. N. SNYDER. *Phys. Rev.*, **96,** *No.* 5, 1333–4 (*Dec.* 1, 1954).

A programme is described which makes it possible to carry out a phase shift analysis of α-α scattering on the ILLIAC Electronic Digital Computer. In approximately 5–10 min the programme can carry out the analysis in terms of up to 6 phase shifts (δ_0, δ_2, . . . δ_{10}) with a precision comparable to an extremely careful human analysis. The number of scattering angles and the energy of the scattering are limited by 32 and 1·150 MeV, respectively. A.

537.534.75

998. Charge states of heavy-ion beams passing through gases. P. M. STIER, C. F. BARNETT AND G. E. EVANS. *Phys. Rev.*, **96,** *No.* 4, 973–82 (*Nov.* 15, 1954).

Measurements are reported of the fraction of an ion beam in the various charge states (−1, 0, +1, +2) after equilibrium has been established between competing electron capture and loss reactions. The ions H^+, He^+, N^+, Ne^+ and A^+ were passed through the gases hydrogen, helium, nitrogen, oxygen, air, neon and argon. The energy range studied was 20 keV to 250 keV. Under conditions of equilibrium between the singly ionized and neutral states, the velocity dependence of the charge ratios is given by $\sigma_{01}/\sigma_{10} = K_1 v^m$, where σ_{if} is the cross-section for the transition between initial charge i and final charge f, v is the velocity and K_1 and m are constants for each ion-stopping gas combination. The corresponding charge ratio for equilibrium between doubly and singly ionized states is given by $\sigma_{12}/\sigma_{21} = K_2(v - v_c)^m$, where K_2, v_c and m are constants for each ion-stopping gas combination. The values of the constants v_c and m are tabulated. Negative ions are detectable only in the hydrogen beams. They constitute approximately 1% of the beam at 30 keV, and decrease in number rapidly at higher energies. A.

537.534.8

999. Angular distribution of secondary ions in the bombardment of a tantalum target with ions of alkali metals. U. A. ARIFOV AND A. KH. AYUKHANOV. *Zh. éksper. teor. Fiz.*, **27,** *No.* 1(7) 87–93 (1954) In Russian.

The energy and intensity distribution of secondary ions of Na and Rb ions was investigated in dependence on the angle of incidence of the primary, and angle of emission of the secondary, ions in the bombardment of a pure heated tantalum target. An angular relation

of the maximum energy of the scattered ions was established, this maximum coinciding with the values of the energy of the elastic impact of colliding particles. A linear relation between the intensity of the secondary ions and their emission angle was also found to exist. The number of secondary ions emitted in the direction of the perpendicular to the target is independent of the angle of incidence of the primary ions whereas the number of secondary ions emitted under various angles does not follow the cosine law and may in a first approximation be represented by a linear law. B. F. KRAUS

DISCHARGE TUBES . COUNTERS 537.54

537.542

1000. The efficiency of halogen-quenched Geiger-counters for X-rays. D. VAN ZOONEN. *Appl. sci. Res. B*, **4**, *No.* 3, 196–204 (1954).

The efficiency of two argon-bromine counters is determined for Mo K_α, Cu K_α and Cr K_α quanta as a function of the overvoltage and as a function of the distance from the axis where the quanta are absorbed. The efficiency drops sharply at greater distances from the wire. This effect is partially ameliorated at higher overvoltages. The more energetic X-ray quanta show a higher relative efficiency in the outer regions. The explanation is to be found in the electronegativity of the halogens. A.

537.542

1001. Production of oscillations in halogen-quenched G.M. counters. D. H. LE CROISSETTE. Letter in *Rev. sci. Instrum.*, **25**, *No.* 10, 1023 (*Oct.*, 1954).

A discussion of various collision processes occurring in Ne–Br_2 filled counters, and when this filling is changed to Ne–Br_2–A (e.g. Penning effect and change of charge reaction). J. D. CRAGGS

537.542

1002. A high sensitive G-M counter for semi-hard X-ray beam and its application. S. TANAKA, T. NASU AND T. YAMADA. *Technol. Rep. Osaka Univ.*, **3**, *No.* 55, 1–4 (*March*, 1954).

An efficiency of more than 20% may be expected for X-rays of energy up to 100 kV. Its efficiency mainly depends upon the photoelectric effect on the cathode of X-rays. The practical construction of the counter and possible applications are briefly described. A.

537.542

1003. Instability in methylal quenched X-ray detectors. S. FINE AND C. F. HENDEE. Letter in *Rev. sci. Instrum.*, **25**, *No.* 8, 830 (*Aug.*, 1954).

An instability in methylal-quenched Geiger counters was eliminated by the addition of methylene bromide and with a pre-treatment of the tube in bromine. The instability which, it is suggested, is due to surface effects, is briefly discussed. J. D. CRAGGS

537.542

1004. Response of activated borazole to radiation. J. I. HOOVER AND C. F. DOHNE. Letter in *Rev. sci. Instrum.*, **25**, *No.* 9, 922–3 (*Sept.*, 1954).

It was found that borazole ($B_3N_3H_6$) is of limited use as a liquid scintillation detector of neutrons in the presence of γ-rays.

537.542

1005. Scintillation counting of low-energy photons and its use in X-ray diffraction. J. C. M. BRENTANO AND I. LADANY. Letter in *Rev. sci. Instrum.*, **25**, *No.* 10, 1028–9 (*Oct.*, 1954).

Very small samples (0·006 cm³) of NaI–Tl crystals used as detectors of Mo Kα X-rays at diffraction goniometer slits avoid large volume detectors and consequent backgrounds. Background is also improved by reducing amplifier time constants to <40 μsec. Response is linear over a wide range (1–20 000 counts/sec). G. F. J. GARLICK

537.542

1006. Efficient, fast, energy-sensitive γ-ray counters for use above 50 MeV. G. E. PUGH, D. H. FRISCH AND R. GOMEZ. *Rev. sci. Instrum.*, **25**, *No.* 11, 1124–6 (*Nov.*, 1954).

Two counters are described. One uses a low Z scintillating liquid to measure the energy loss of an electron pair; the other uses high Z material to develop a shower which is sampled with scintillating plastic sheets. Curves of the experimental performance are included. A.

537.542 : 621.387.464

1007. Low energy measurements with the photomultiplier scintillation counter. G. T. WRIGHT. *J. sci. Instrum.*, **31**, *No.* 12, 462–5 (*Dec.*, 1954).

The method of statistical generating functions is used to investigate the process of cascade multiplication. The equations developed are used to examine the nature of the pulse height distribution curve from the scintillation counter and to evaluate the counting efficiency of this instrument. It is found that the maximum of the distribution may be displaced considerably from the position of the mean, and curves are drawn to illustrate this. The effects of non-uniform photocathode and dynode surfaces are investigated. They are concluded to have little influence compared with the normal statistical processes. A.

537.542

1008. A note on cloud-chamber illumination systems. J. K. DE PAGTER AND B. F. STEARNS. Letter in *Rev. sci. Instrum.*, **25**, *No.* 9, 921 (*Sept.*, 1954).

Briefly discusses the use of immersion lenses in optical systems used in Wilson chamber illumination. J. D. CRAGGS

IONIZATION . THERMIONICS 537.56/.58

537.562

1009. On the movement of electricity. J. J. GRUETZMACHER. Note in *Naturwissenschaften*, **41**, *No.* 16, 368 (1954) In German.

A brief note discussing, generally, certain aspects of the transport of charged particles as in a moving ionized gas. J. D. CRAGGS

537.564

1010. Ionization and fragmentation of CO by bombardment with atomic ions. Dissociation energy of CO. Heat of sublimation of carbon. E. LINDHOLM. *Ark. Fys.*, **8**, *Paper* 42, 433–40 (1954).

The charge exchange in collisions between atomic ions and CO molecules has been investigated. The fragments CO^+, O^+ and C^+ from the molecule have been analysed in a second mass spectrometer. The fragmentation processes are discussed on the basis of the known ionization potentials of CO and the known appearance potentials of O^+ and C^+. In collisions with Ne^+ the cross-section for formation of C^+ is rather large. As the recombination energy for Ne^+ is 21·6 eV, the fragmentation process must correspond to the appearance potential 20·9 eV for C^+. Previously it has been assumed that in this process an excited O^- ion is formed, but as the primary process in the present experiments is charge exchange, the other fragment must be a neutral O atom. These results support the value 9·605 eV for the dissociation energy of CO and 135·7 kcal/mol for the heat of sublimation of carbon given by Lozier and Hagstrum but, on the other hand, they throw doubt on their assumption concerning the existence of an excited state of O^-. A.

537.564

1011. Ionization and dissociation by electron impact; methylene, methyl, and methane. A. LANGER, J. A. HIPPLE AND D. P. STEVENSON. *J. chem. Phys.*, **22**, *No.* 11, 1836–44 (*Nov.*, 1954).

The appearance potentials of C^+, CH^+ and CH_2^+ in the mass spectra of methylene, methyl and methane are found to be mutually consistent and when combined with the spectroscopic value of the ionization potential of the carbon atom (11·26 eV) lead to 15·5 ± 0·5 eV/molecule for the heat of atomization of methane. This value (15·5) when further combined with the heat of formation of methane (— 0·78 eV/molecule) and the dissociation energy of H_2 (4·48 eV/molecule) yields 5·7$_6$ eV/atmos or 133 kcal/mole for the heat of sublimation of graphite. A.

537.564

1012. Electron impact studies of some aromatic hydrocarbons. Implications regarding certain aromatic reactions. F. H. FIELD AND J. L. FRANKLIN. *J. chem. Phys.*, **22**, *No.* 11, 1895–904 (*Nov.*, 1954).

The ionization potential of several alkyl-substituted aromatics have been measured by an electron impact method, and the results are found to agree with values predicted by equivalent orbital calculations. The appearance potential of several alkyl-substituted benzyl ions have been measured, and the results show that the energies of these ions are independent of ring substitution. The appearance potential of several alkyl-substituted phenyl ions were measured, and the results appear to be anomalous. The results can be understood if it is assumed that the ions rearrange during decomposition to the isomeric benzyl ions. The implications of these results in terms of several chemical reactions are discussed. The heat of formation of the phenyl and ethyl phenyl radicals were found to be approximately 66 and 49 kcal/mole, respectively. A.

537.564

1013. Inelastic heavy-particle collisions involving the crossing of potential energy curves. II. Charge transfer from H-atoms to Al^{3+}, B^{2+}, Li^{2+} and Al^{2+}. A. DALGARNO. *Proc. Phys. Soc.* [*London*] *A*, **67**, *Pt* 11, 1010–17 (*Nov.*, 1954).

For Pt I, see Abstr. 11167 (1954). The charge-transfer processes $H + Al^{3+} \rightarrow H^+ + Al^{2+}(^2S$ and $^2P)$, $H + B^{2+} \rightarrow H^+ + B^+(^1P)$, $H + Li^{2+} \rightarrow H^+ + Li^+(^3S$ and $^1S)$ and $H + Al^{2+} \rightarrow H^+ + Al^+$ are investigated using the Landau–Zener formula for the transition probability arising from the pseudo-crossing of the potential energy curves of the initial and final systems. These pseudo-crossings occur at nuclear separations of 3·34, 6·58, 11·1, 8·88, 20·9 and 5·29 atomic units respectively, and the corresponding energy separations due to the interaction between the initial and final states are 5·18, 1·25, $5{\cdot}69\times10^{-3}$, $1{\cdot}24\times10^{-1}$, $2{\cdot}12\times10^{-6}$ and 1·54 eV. The cross-sections associated with the six processes are calculated over a wide range of impact energies. The relationship between energy excess and energy separation is briefly discussed in an appendix. A.

537.564

1014. Ionization produced by 5-MeV alpha particles in argon mixtures. C. E. MELTON, G. S. HURST AND T. E. BORTNER. *Phys. Rev.*, **96**, *No.* 3, 643–5 (*Nov.* 1, 1954).

It is shown that when small amounts of impurities are added to argon extra ionization is produced by α-particles moving through the gas. These effects are studied as a function of the ionization potential of the added impurity and it is found that the ionization increases even when the ionization potential is much higher than the well-known metastable state of argon. A.

537.568

1015. On the stability of the negative lithium ion. E. HOLØIEN. *Arch. Math. Naturvid.*, **52**, *No.* 1–2, *Paper* 7, 74–94 (1954).

A variational calculation gives a value of + 0·3 eV for the electron affinity of Li^-. A variable parameter has been introduced into the wave-functions used, which takes account of interelectronic correlations. Formulae are given for the evaluation of the necessary integrals. A. J. TAYLOR

537.58 : 537.525 : 621.385.032.216

1016. The emission from hot cathodes in gas discharges. A. E. PENGELLY AND D. A. WRIGHT. *Brit. J. appl. Phys.*, **5**, *No.* 11, 391–5 (*Nov.*, 1954).

This was studied over a wide range of current and its stability examined. The condition of zero field thermionic emission was identified in the presence of a discharge in inert gas. For all types of cathode investigated, the emission at zero field in the discharge was similar to that obtained in vacuum. At very high currents, the electron emission is greater than the thermionic emission, either because of enhancement by the field or because of γ-effects at the cathode. A.

537.581

1017. Thermoelectronic emission in ferromagnetics. A. V. SOKOLOV AND A. Z. VEKSLER. *Zh. éksper. teor. Fiz.*, **25**, *No.* 2(8) 215–24 (1953) In Russian.

Single-electron wave-functions for solids, not

involving the introduction of the potential jump, are used for describing thermoemission in metals. The results are used for evaluating the current in ferromagnetics on the basis of Vonsovskii's (*s–d*)-exchange model [*Zh. éksper. teor. Fiz.*, **16**, 981 (1946)] which explains thermoemission as a result of interaction between two electron gases ("*s*" and "*d*"). Results of a previous research [Abstr. 7364 (1952)] are given a theoretical explanation. F. LACHMAN

537.581

1018. Anomalies of the electron emission of tungsten heated by a current pulse of high density. S. V. LEBEDEV AND S. É. KHAĬKIN. *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 723–35 (1954) In Russian.

Flash discharges occur on the surface of W and Fe wires heated in vacuum by current pulses of 10^7 A/cm^2, but it is possible to select the time relation of the current density in such a way that no discharges occur on very short tungsten wires. The discharge could so be traced back to the emergence of very large numbers of electrons at the surface of the wire, whereas only negligible numbers of ions are observed. This proves that the electrons are actually emitted by the wire and are not produced by ionization of metal vapours or adsorbed gases. The density of the electron emission current may be 100 times higher than the saturation current density from melting tungsten. That this electron emission causes the discharge could be proved beyond doubt. Except for the instant of the initiation of the discharge, the phenomena are analogous for Fe wires so that the discharge in this case is also due to a quite anomalously strong electron emission.

B. F KRAUS

COSMIC RAYS 537.591

537.591.1

1019. Low energy differential range spectrum of cosmic-ray μ mesons. A. FAFARMAN AND M. H. SHAMOS. *Phys. Rev.*, **96**, *No.* 4, 1096–9 (*Nov.* 15, 1954).

The differential range spectrum of cosmic-ray μ-mesons was investigated in the region from 0 to 410 g/cm^2 Pb for evidence of minima. Delayed coincidences in a tank of liquid scintillator were used to identify stopping mesons. The spectrum decreases monotonically with decreasing energy and shows no irregularity. Although only relative readings were taken, the method is adaptable to a precision determination of the absolute range spectrum. The delay data yield for the natural mixture of sea-level cosmic-ray μ-mesons a mean life in carbon of $2{\cdot}13 \pm 0{\cdot}07$ μsec. A.

537.591.1

1020. The alpha-particle component of the cosmic radiation. C. J. WADDINGTON. *Phil. Mag.*, **45**, 1312–21 (*Dec.*, 1954).

For investigating the primary α-component a nuclear emulsion technique was employed. A value of 60 ± 17 g/cm^2 was found for the collision mean free path of α-particles in emulsion. The justification for using this value to obtain values for the mean free paths in other media is discussed. A value of 320 ± 36 α-particles per m^2 per steradian per sec was found for the primary flux at a geomagnetic latitude of 55°N. This was in agreement with previous values. The energy distribution found was in agreement with that for the heavy primaries ($Z \geqslant 3$) given by Dainton *et al.* (1952) and Gottstein (1954). A.

537.591.1

1021. Interaction of heavy primary cosmic rays in lead. Y. EISENBERG. *Phys. Rev.*, **96**, *No.* 5, 1378–82 (*Dec.* 1, 1954).

The energy spectrum of heavy primary cosmic-ray nuclei was measured and found to be in agreement with the assumption that no primaries with energy below the geomagnetic cutoff enter the earth. The mean free path of the primary nuclei in lead was measured. If the transparency of nuclear matter is taken into account, the present results for lead and the measurements by others for lighter elements are in good agreement. If the expression $R_A = R_0 \times A^{\frac{1}{3}}$ is used for the radius of the nucleus, the data indicate for R_0 the value $1{\cdot}3 \times 10^{-13}$ cm. It is also shown that the ratio of the abundances of the charge groups $Z = 12$ to 17 and $Z = 18$ to 28 is $\sim 2{\cdot}1$. A.

537.591.1

1022. Composition of the primary cosmic radiation at λ = 10°N. G. W. MCCLURE. *Phys. Rev.*, **96**, *No.* 5, 1391–400 (*Dec.* 1, 1954).

A balloon-borne instrument comprising a fast ionization chamber interposed in a G.M. counter train has been flown near the geomagnetic equator for the purpose of determining the fluxes of protons and He nuclei in the primary cosmic radiation. The apparatus measures the specific organization of each particle that traverses the telescope, and contains a shower detector to aid in the identification of multiple-particle events of either local or external origin. Under the assumption that all telescope coincidences resulted from particles incident within the counter-defined solid angle, the total vertical flux, extrapolated to the "top of the atmosphere," is $I_{\text{total}} = 260$ sterad^{-1} m^{-2} sec^{-1}. The "top"-extrapolated fluxes of primary protons and He nuclei deduced from the ionization distributions recorded at various depths (17 g/cm^2 and greater) are as follows: $I_H < 145$ sterad^{-1} m^{-2} sec^{-1}; $I_{\text{He}} < 38$ sterad^{-1} m^{-2} sec^{-1}. The large difference between I_{total} and $(I_{\text{H}} + I_{\text{He}})_{\text{max}}$ is believed to arise from air showers and/or nuclear events produced by particles incident from outside the telescope solid angle. The consequences of neglecting these spurious effects in interpreting counter-telescope measurements are discussed with particular reference to influences on the deduced form of the primary-proton energy spectrum, and the total energy flux associated with the primary radiation. A.

537.591.1

1023. Abundance of lithium, beryllium, and boron in the primary cosmic radiation. M. F. KAPLON, J. H. NOON AND G. W. RACETTE. *Phys. Rev.*, **96**, *No.* 5, 1408–16 (*Dec.* 1, 1954).

The flux of nuclei of charge greater than two of the primary cosmic radiation has been measured at 41° and 55° geomagnetic latitudes with photographic emulsions flown in "Sky Hook" balloons. The technique used at the lower latitude is similar in principle

to that employed originally by Bradt and Peters, while that used at the higher latitude is the method of Dainton, Fowler and Kent. The different experimental methods are discussed and the latter is found more satisfactory for the light-element problem. Primary flux values are reported for the medium nuclei ($6 \leqslant Z \leqslant 10$) and the heavy nuclei ($Z > 10$) at the two latitudes. It is concluded that there exists a finite primary flux of the light nuclei ($3 \leqslant Z \leqslant 5$) and the most reliable value from these experiments of the ratio of the primary light-nuclei flux N_L^0 to the primary medium-nuclei flux N_M^0 at the top of the atmosphere is found to be $0{\cdot}46 \pm 0{\cdot}15$. A.

537.591.15

1024. Two simple stochastic models of cascade multiplication. A. Ramakrishnan and S. K. Srinivasan. *Progr. theor. Phys.*, **11**, *No.* 6, 595–603 (*June*, 1954).

Numerical results are obtained in regard to two simple stochastic models of cascade multiplication. It is shown that these models reveal many interesting features characteristic of more complicated multiplicative processes like the well-known stochastic process of cosmic-ray cascades. A.

537.591.15

1025. The sidereal correlation of extensive air showers. F. J. M. Farley and J. R. Storey. *Proc. Phys. Soc.* [*London*] *A*, **67**, *Pt* 11, 996–1004 (*Nov.*, 1954).

About 3×10^5 extensive air-shower events were recorded at Auckland (altitude 40 m, latitude 37°s) with 3 counter trays at the corners of a 4 m triangle, each of sensitive area 2360 cm², in the period February 1951 to February 1952. The results show a solar diurnal amplitude of $(1{\cdot}45 \pm 0{\cdot}25)\%$ with maximum at $(2{\cdot}7 \pm 0{\cdot}6)$ hours local solar time and a sidereal diurnal amplitude of $(1{\cdot}10 \pm 0{\cdot}26)\%$ with maximum at $(19{\cdot}8 \pm 0{\cdot}9)$ hours local sidereal time (standard errors). By introducing the concept of antisidereal time (there are 364·2 antisidereal days per year) an allowance is made for the seasonal amplitude modulation of the solar diurnal variation. When this correction is applied, the true sidereal diurnal amplitude becomes $(1{\cdot}43 \pm 0{\cdot}38)\%$ with maximum at $(17{\cdot}6 \pm 1{\cdot}0)$ hours local sidereal time. The results indicate a maximum in the cosmic-ray intensity when the galactic plane is overhead. A.

537.591.15

1026. Time variations of extensive air showers and the origin of cosmic rays. T. E. Cranshaw and W. Galbraith. *Phil. Mag.*, **45**, 1109–18 (*Nov.*, 1954).

An experiment is described in which sixteen Geiger counters each of area 200 cm² arranged on a square lattice of 54 m pitch were used in coincidence to count showers of energies about 10^{16}, 2×10^{16}, 5×10^{16} and 10^{17} eV. From the shower rates, no evidence of a deviation from the power law spectrum, $R(> E) \propto E^{-1{\cdot}7}$, was found. The results are analysed in solar and sidereal time. In solar time no variations greater than 1% for the 10^{16} eV showers or 10% for the 10^{17} eV showers were found, and these amplitudes could easily arise as a result of statistical fluctuations. In sidereal time, no variation greater than 0·6% was observed at an energy of 10^{16} eV. At 2×10^{16} and 5×10^{16} eV, small variations were observed which had about 1% chance of being due to random fluctuations. The bearing of these results on theories of the origin of cosmic rays is discussed. A.

537.591.15

1027. Bursts in NaI(Tl) near sea level. S. Standil. *Phys. Rev.*, **96**, *No.* 3, 777 (*Nov.* 1, 1954).

The spectrum of cosmic-ray events induced in a NaI(Tl) scintillation spectrometer has been observed near sea level. The high-energy bursts so observed are interpreted as due mainly to nuclear interactions in the crystal with an energy distribution given by the power law $N(E)dE \propto E^{-3{\cdot}6}dE$. The attenuation length for the star-producing component in concrete is found to be 200 ± 25 g/cm². A.

537.591.15 : 519.2

Stochastic processes in cascade theory. *See Abstr.* 685

537.591.3

1028. The lead absorption of cosmic rays. P. S. Gill. *Indian J. Phys.*, **28**, *No.* 7, 335–44 (*July*, 1954).

Detailed measurements of the absorption of cosmic rays in lead have been made at Gulmarg (8890 ft), Srinagar (5000 ft), Aligarh (600 ft), and Swarthmore (296 ft) with a view to determining the reported anomalies in the lead absorption curves at low latitudes. The data do not bring out any abnormality in curves other than at Gulmarg, where there is an indication of a dip at $p/\mu = 0{\cdot}557$ BeV/c corresponding to 35 cm lead thickness. A.

537.591.5

1029. The influence of meteorological factors on the latitude effect of the hard component of cosmic rays and the process of the generation of mesons. L. I. Dorman. Letter in *Zh. éksper. teor. Fiz.*, **26**, *No.* 4, 504–5 (1954) In Russian.

The author's recent work [*Dokl. Akad. Nauk, SSSR*, **94**, *No.* 3, 433; **95**, *No.* 1, 49 (1954)] makes it possible to correct the latitude effect for the increase of intensity associated with the temperature variation from the equator to $\lambda = 55°$ (some 4%). The corrected intensity levels off very clearly between 35°–40°, corresponding to a minimum primary proton energy of $6–8 \times 10^9$ eV. This is interpreted as meaning that protons with less energy cannot generate μ-mesons with energy $> 2 \times 10^9$ eV, necessary for their detection at sea level. W. J. Swiatecki

537.591.5

1030. The variation of the intensity of cosmic rays and the role of meteorological factors. L. I. Dorman, A. I. Kuz'min, G. V. Tyanutova, E. L. Feinberg and Yu. G. Shafer. *Zh. éksper. teor. Fiz.*, **26**, *No.* 5, 537–44 (1954) In Russian.

In discussing the temperature and barometric effects on the variation of the intensity I of the hard component of cosmic rays, one must allow for (*a*) the dependence of the meson lifetime on its energy and (*b*) the temperature distribution of the entire atmosphere over the point of observation. (Seasonal variations in the temperature may have the opposite sign at sea level and in the stratosphere.) Several erroneous conclusions in the literature concerning the seasonal variation of intensity can be ascribed

to the disregard of these effects [e.g. Dolbear and Elliot, Abstr. 6306 (1951); Duperier, 2814 (1952)]. By taking them into account it is possible to deduce a formula for the effect of meteorological factors on I [L. I. Dorman, *Dokl. Akad. Nauk, SSSR*, **94**, 433 (1954)] which agrees to within 0·1–0·2% with the observed annual variation of some 2%. This is illustrated with reference to 3 stations in U.S.S.R. and one (at Cheltenham) in U.S.A. Recent precision measurements have made it possible to detect also a daily variation in I with an amplitude 0·2%, partly masked by meteorological factors. W. J. SWIATECKI

537.591.5

1031. Anisotropy of high-energy cosmic rays. L. DAVIS, JR. *Phys. Rev.*, **96**, *No.* 3, 743–51 (*Nov.* 1, 1954).

Review of the evidence indicates that a magnetic field of the order of 10^{-5} gauss probably lies along a spiral arm of the galaxy. If so, any anisotropy observed in high-energy cosmic radiation must be associated with this field. Anisotropy might be due to: (*a*) acceleration by Fermi's mechanism, either by his longitudinal collisions or by betatron effects; (*b*) diffusion along field lines toward a region where the cosmic rays escape from the galaxy; (*c*) inhomogeneities in cosmic-ray density normal to the field lines. From symmetry considerations theoretical expressions are developed for the cosmic-ray flux as a function of direction and for the resulting sidereal time dependence of extensive showers as a function of latitude and the orientation of the detecting apparatus. If atmospheric effects can be corrected for, the main harmonics predicted are the first and second, the second being mainly due to anisotropy produced by acceleration. In the absence of detailed calculations based on a specific theory of the origin of cosmic rays and on the way the extensive showers are detected, the amplitude of the harmonics must be determined from experiment. Preliminary reports of measurements by Cranshaw and Galbraith and by Farley and Storey seem to indicate tentatively that the magnetic field is as described above and that cosmic rays are accelerated by Fermi's mechanism; the measurements of Daudin and Daudin require some other explanation. A.

537.591.5

1032. Changes in amplitude of the cosmic-ray 27-day intensity variation with solar activity. P. MEYER AND J. A. SIMPSON. *Phys. Rev.*, **96**, *No.* 4, 1085–8 (*Nov.* 15, 1954).

Both cosmic-ray neutron and ionization-chamber intensity observations reveal that the amplitude of the 27-day recurring intensity variation has been changing over an interval of several years. A method for studying this phenomenon using ionization chamber data for the period 1936–1946 and neutron intensity data for 1951–1953 is described which not only selects preferentially the 27-day variations but also selects the variations which are world wide. The amplitude of the 27-day intensity variation over these years displays minima and a maximum closely related in time to the minima and maxima of the approximately 11-year cycle in general solar activity. Thus, these results provide additional, and independent, evidence that solar active regions are responsible for producing the mechanism which controls the 27-day cosmic-ray primary intensity variations. A.

537.591.5

1033. Cosmic-ray intensity fluctuations at sea level. R. L. CHASSON. *Phys. Rev.*, **96**, *No.* 4, 1116–23 (*Nov.* 15, 1954).

Geomagnetic and atmospheric influences on sea-level cosmic radiation have been studied at Berkeley, California (95 m elevation, 44° N geomagnetic latitude). The hard (20 cm lead absorber) and total intensities were measured with wide-angle triple-coincidence counter telescopes, and fluctuations of intensity were compared statistically with changes of barometric pressure, pressure-altitude, and temperature of the lower stratosphere. The atmospheric coefficients found by Duperier were verified for the 100-millibar region, but radiosonde data were not complete enough to permit calculations for higher strata of the atmosphere. The hard and total intensity data, corrected to constant barometric pressure, were examined for fluctuations that could be correlated with geomagnetic disturbances. No apparent cosmic-ray changes accompanied any of seven geomagnetic sudden commencements. Of eighteen magnetic storm periods occurring over eight months, only four appeared definitely to be accompanied by cosmic-ray intensity decreases. No increases of intensity occurred during these periods. Of the four decreases observed, two were unusual in that the decrease occurred an appreciable time before the measurable geomagnetic disturbance (May 27 and June 25, 1951). These two events occurred during times of very great sunspot activity, but only a loose genetic relationship could be established between the sunspot behaviour and the prestorm cosmic-ray decreases. A.

537.591.8

1034. On cosmic rays jets. G. BERTOLINO AND D. PESCETTI. *Nuovo Cimento*, **12**, *No.* 5, 630–8 (*Nov.*, 1954).

Twenty-nine jets found in the plates which have been launched at Cagliari in summers of 1952 and 1953 have been studied. The mean energy for mesons emitted in each jet is calculated after introduction of the anelasticity coefficient; it is inferred that the values for said energy in the low multiplicity jets are slightly greater than in high multiplicity jets. Angular distribution in the jets is studied; the results do not disagree with an isotropic distribution. A.

537.591.8

1035. A cloud chamber study of cosmic ray interactions underground. H. J. J. BRADDICK AND B. LEONTIC. *Phil. Mag.*, **45**, 1287–92 (*Dec.*, 1954).

A multiplate cloud chamber has been used to study the interactions of cosmic rays underground. The nature of events previously reported as pairs of associated penetrating particles (A.P.P.) is discussed and an upper limiting cross-section for the formation of such particles is estimated as 2×10^{-30} cm^2 per nucleon. An explanation of the high cross-section found previously is put forward. A cross-section of $3\cdot2 \pm 1\cdot8\times10^{-30}$ cm^2 per nucleon for the nuclear

interaction of cosmic rays underground has been obtained. A.

537.591.8

1036. Production spectra of cosmic-ray mesons in the atmosphere. S. OLBERT. *Phys. Rev.*, **96**, *No.* 5, 1400–7 (*Dec.* 1, 1954).

Recent experimental data on the differential vertical intensities of μ-mesons in the atmosphere make it possible not only to improve the original Sands' production spectrum of μ-mesons, but also to study its dependence on the geomagnetic latitude. It is shown that, for the residual ranges, R', between 100 g cm^{-2} and 6000 g cm^{-2}, the production spectrum may be approximated by an empirical formula of the type: $C(a + R')^{-\gamma}$ where C and γ are numerical constants practically independent of the geomagnetic latitude. The latitude dependence of the production spectrum is thus expressed through the parameter a which displays a monotonic decrease with increasing latitude. With numerical values of a, C and γ, compatible with experimental data, the production spectrum of μ-mesons is then used as a basis for the derivation of the differential and integral energy spectra of charged π-mesons. The latitude dependence of the π-meson spectrum is linked to the geomagnetic cutoff of the primary cosmic radiation, which leads to some crude conclusions on the average multiplicity of π-mesons produced in proton collisions with air nuclei. In particular, the dependence of the multiplicity on the primary energies between 2 and 13 BeV is studied in detail and compared with Fermi's statistical theory of π-meson production. A.

MAGNETISM 538

538.1 : 622.778

1037. The theory of dry magnetic mineral dressing of finely dispersed strongly magnetic material. E. LAURILA. *Ann. Acad. Sci. Fennicae, AI, Paper* 171, 26 *pp.* (1954) In German.

Gives an account of the magnetostatic principles applied to the properties of magnetic powders in steady and in rotating magnetic fields, and applies the results to the design of a magnetic separator of use in mineral dressing. E. P. WOHLFARTH

538.11

1038. Dipole distributions. E. DURAND. *Ann. Phys.* [*Paris*] **9**, 493–523 (*Sept.–Oct.*, 1954) In French.

Derives formulae for the Hertz vector, scalar and vector potential, and electric field and displacement vector for a variety of one, two and three dimensional dipole distributions. [The results are standard.]

E. P. WOHLFARTH

538.11 : 538.22

1039. Antiferromagnetism. T. NAGAMIYA, K. YOSIDA AND R. KUBO. *Advances in Physics*, **4**, 1–112 (*Jan.*, 1955).

An extensive review of the following topics: I. *Fundamental facts and elementary theory.* Neutron and X-ray diffraction measurements; susceptibility and specific heat determinations (a table gives magnetic data and an extensive bibliography, 112 references, for a wide variety of substances); theory of susceptibility at low fields (molecular field approximation) and at moderately high fields (effects of anisotropy); antiferromagnetic resonance (with application to $CuCl_2$); transition to paramagnetic behaviour in high fields. II. *Indirect exchange interaction and anisotropy energy.* Superexchange and double exchange interactions (outline of quantum mechanical calculations); origins of anisotropy energy and application of the theory of anisotropy to $CuCl_2$ and fluorides of Mn, Fe, Co. III. *Statistical theory of antiferromagnetism.* Ising model; high temperature approximations (Bethe–Peierls–Weiss); low temperature approximations (linear chain model of Bethe and Hulthén), the antiferromagnetic ground state; semi-classical and quantum-mechanical formulations of the spin-wave theory and consequences of the theory (specific heat, sublattice magnetization, susceptibility); limitations of the spin-wave theory. 28 figures, 184 references. E. P. WOHLFARTH

538.114

1040. Zener's theory of ferromagnetism. E. A. TUROV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 3(9) 352–8 (1953) In Russian.

Zener's theory [Abstr. 2832 (1952)] is analysed from the point of view of the (*s-d*)-exchange model of transition metals. The temperature dependence of spontaneous magnetization at low temperatures, as calculated in accordance with Zener's assumptions, widely differs from experimental values. Zener's theory cannot be applied to ferromagnetics, at least to those in which magnetization obeys the $T^{3/2}$ law.

F. LACHMAN

538.114

1041. Ferromagnetism of substances of ferrite type and antiferromagnetism. K. B. VLASOV AND B. KH. ISHMUKHAMETOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 1(7) 75–86 (1954) In Russian.

Above the antiferromagnetic Curie point the permeability follows the Curie–Weiss law, the paramagnetic Curie point differing from the antiferromagnetic one. Theoretically this indicates exchange interaction not only between sublattices but also inside the sublattices themselves. Below the antiferromagnetic Curie point the permeability is anisotropic, the perpendicular permeability being independent of temperature, and the parallel permeability dependent; the latter tends towards zero at 0°K and towards the value of the perpendicular permeability at the antiferromagnetic Curie point. The form of the temperature curve of the parallel (or resultant) permeability is determined by the ratio of the values of paramagnetic and antiferromagnetic Curie points; the smaller this ratio, the greater the slope of the curve referred to the temperature axis near the Curie point. These results agree with Neel's and van Vleck's conclusions based on the method of molecular fields. Certain differences exist for such materials as MnF_2 and FeF_2, but they are partly due to disagreements between experimental conditions which render correct comparisons difficult and the theory has so far been evolved only for a somewhat limited temperature range. B. F. KRAUS

538.114

1042. On the spin wave field theory and its application to the microwave resonance. N. TSUYA. *Progr. theor. Phys.*, **12**, *No.* 1, 1–9 (*July*, 1954).

An exact operator system describing spin systems such as the ferro-, ferri- and antiferromagnetic was obtained, in which spin S need not be equal to one half. The field operators adopted here are well-known annihilation and creation operators usually used for the Bose field, with subsidiary conditions limiting the infinite space of numbers to a finite value of $2S + 1$. Exact solutions of these Hamiltonians, of course, cannot be obtained because their form is not bi-linear, but they are solved approximately in the case of low temperatures. The resonance conditions obtained by this method for ferro-, ferri- and antiferromagnetic cases are the same as those already obtained from the Heisenberg equation of motion. A.

538.114

1043. Susceptibilities of antiferromagnetic crystals at the absolute zero of temperature. T. VAN PESKI-TINBERGEN AND C. J. GORTER. *Physica*, **20**, *No.* 9, 592–602 (*Sept.*, 1954).

On the basis of the molecular field theory of antiferromagnetism, calculations are made on magnetic susceptibilities at absolute zero. Rhombic and cubic symmetries are considered with constant fields in the direction of the axes. Besides the threshold phenomena the anomalies occurring when antiferromagnetism goes over into paramagnetism are considered. A.

538.114

1044. Reversible susceptibility of ferromagnetics. D. M. GRIMES AND D. W. MARTIN. *Phys. Rev.*, **96**, *No.* 4, 889–96 (*Nov.* 15, 1954).

An expression is given relating the magnetization dependence of the reversible susceptibility normal to the field direction to that of the parallel reversible susceptibility. Modification of these susceptibility dependences due to the trapping of domain walls in metastable positions by potential holes is considered. The macroscopic magnetization is expressed in terms of a distribution of potential holes by an argument analogous to that of a "mean free path." The desirability of further examination of this approach is discussed. The reversible susceptibilities of three ferrite specimens were measured and found to compare favourably with the theory. A.

538.114 : 536.7

1045. Effects of anisotropy on thermodynamic properties of antiferromagnets. J. A. EISELE AND F. KEFFER. *Phys. Rev.*, **96**, *No.* 4, 929–33 (*Nov.* 15, 1954).

In antiferromagnets, because of interplay with exchange energy, a small anisotropy can have a huge effect on thermodynamic properties. Detailed calculations are given, using spin-wave theory, of this effect on sublattice magnetization, specific heat and parallel susceptibility of a cubic or uniaxial antiferromagnet. Specific heat data is discussed and experiments are suggested on the relatively large spin specific heats of antiferromagnets with low Curie points. The theory is extended to orthorhombic symmetry, and reasonable agreement found with existing experimental data on $CuCl_2.2H_2O$. A.

538.122

1046. Topology of steady current magnetic fields. K. L. MCDONALD. *Amer. J. Phys.*, **22**, *No.* 9, 586–96 (*Dec.*, 1954).

Textbooks often hold erroneously that the condition $\nabla.H = 0$ implies that lines and tubes of force are closed. Examples are given in which the lines of force are not only unclosed, but also, the density of lines may be made infinite in a region where the field intensity is finite. If the steady electric current density is everywhere finite, the magnetic field has singularities only at discrete points, lines or surfaces, where $H = 0$. In general, an infinity of lines of force may terminate on these points. Lines of force may have finite length, going from one singularity to another. A systematic analysis is made of the allowed distribution of singular points, and the linear fields in the neighbourhoods of these points are classified. Certain types of singularities may appear in regions of finite current density, but cannot occur in regions free of current. Lines of force may form limit cycles. A.

538.221

1047. Magnetic powder patterns on martensite. W. ANDRÄ. *Ann. Phys.* [*Leipzig*] **15**, *No.* 1, 31–4 (1954) In German.

Gives results for a steel specimen containing large martensite inclusions in an austenitic matrix. The patterns were obtained after mechanical and electrolytic polishing; the effect of application and reversal of a magnetic field perpendicular to the specimen surface was also investigated. The patterns show no presence of domain boundaries, and it is suggested that the martensite inclusions have single easy axes of magnetization with high magnetocrystalline anisotropy, as in cobalt. E. P. WOHLFARTH

538.221

1048. On the internal field of the microwave resonance in ferrites. N. TSUYA. Note in *J. Phys. Soc. Japan*, **9**, *No.* 4, 644–5 (*July–Aug.*, 1954).

The anomalously low g factor for low frequency electron resonance in ferrites has been attributed to the presence of an internal field [Abstr. 1747 (1953)] and it is suggested that this might arise from free charges on the surface of internal cracks in the crystal. D. H. WHIFFEN

538.221

1049. Motion of individual domain walls in a nickel-iron ferrite. J. K. GALT. *Bell Syst. tech. J.*, **33**, *No.* 5, 1023–54 (*Sept.*, 1954).

Samples have been cut from single crystals of the nickel-iron ferrite $(NiO)_{0.75}(FeO)_{0.25}Fe_2O_3$ in such a way that they contain one and only one movable ferromagnetic domain wall. The viscous damping coefficient for this wall, which is a measure of the losses associated with domain wall motion in this material, has been measured as a function of temperature. This damping shows a very large increase as the temperature goes down to the region of 77°K. The value of this damping is correlated with the Landau–Lifshitz equation for the rotational motion of magnetization by means of previously available

theoretical analysis. In addition, it is suggested that the sharp increase in damping at low temperatures is due to a relaxation associated with a rearrangement of the valence electrons on the divalent and trivalent iron ions in the ferrite. A tentative phenomenological theory of the losses based on this mechanism is presented. A.

538.221

1050. Magnetic behavior of the system CoO–MgO at elevated temperatures. N. ELLIOTT. *J. chem. Phys.*, **22**, *No.* 11, 1924–5 (*Nov.*, 1954)

The magnetic susceptibilities of solid solutions of CoO and MgO have been measured at elevated temperatures. The data fit a Curie–Weiss law $\chi = C/(T + \theta)$ with $C = 3{\cdot}23 \pm 0{\cdot}04$. θ varies linearly with the mol fraction of CoO. The magnetic measurements indicate that CoO has an antiferromagnetic ordering of spins of the first kind below the Curie point. A.

538.221

1051. Magnetic anisotropy constants of ferromagnetic spinels. R. S. WEISZ. Letter in *Phys. Rev.*, **96**, *No.* 3, 800–1 (*Nov.* 1, 1954).

Calculates values of K_1 for the ferrites $MO.Fe_2O_3$ (M = Mn, Co, Ni, Cu, Mg) from the formula $\mu_0 - 1 = kI_0^2/K_1$ appropriate to a rotational process of magnetization, μ_0 being the initial permeability and k a constant (taken equal to 21 from direct measurements on magnetite). Comparison is made with directly measured values; the calculated values are correlated with the multiplicities of the M^{++} ions in the ground state and with observed values of the magnetostriction constants. E. P. WOHLFARTH

538.221

1052. Ferromagnetic resonance in iron-nickel alloys. R. HOSKINS AND G. WIENER. Letter in *Phys. Rev.*, **96**, *No.* 4, 1153–4 (*Nov.* 15, 1954).

Reports results at wavelength 0·6, 1·2, 3·0 cm for disk-shaped bulk samples [cf. colloidal suspensions, Abstr. 591 (1954)] with Ni concentrations between 36% and 48%. The g values remain practically constant (2·13 at 1·2 cm) over this concentration range. Values of the saturation induction and line widths were also obtained, the latter being unusually low.

E. P. WOHLFARTH

538.221

1053. Measurement of the complex tensor permeability of ferrites. J. H. ROWEN AND W. VON AULOCK. Letter in *Phys. Rev.*, **96**, *No.* 4, 1151–3 (*Nov.* 15, 1954).

Modifies the method of Artman and Tannenwald [Abstr. 8548 (1953)] by using very thin, disk-shaped, rather than small spherical specimens. The advantages of this choice are discussed, and values of the tensor components are given as a function of field strength (up to 4000 oersted). E. P. WOHLFARTH

538.222

1054. Paramagnetic absorption in some Gd salts in parallel fields. N. S. GARIF'YANOV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 3(9) 359–63 (1953) In Russian.

The applicability of Shaposhnikov's theory (*Dissertation*, Moscow University, 1949) and Gorter's empirical formula to the experimentally determined values of paramagnetic absorption in parallel fields at high frequencies ($5{\cdot}46 \times 10^8$ c/s) is checked. It is found that Gorter's formula does not describe the experimental curves at $\sim 10^9$ c/s; Shaposhnikov's simplified formula $\chi''/\chi_0 = (1 - f(F)^2 \rho_s \nu$ applies very well to curves at $\sim 10^9$ c/s. The magnetic heat-capacity constant b/C is calculated to be equal to $\delta^2/0{\cdot}41$, where δ is the half-width of the absorption band. This constant is $3{\cdot}82 \times 10^6$ Oe^2 for $Gd_2(SO_4)_3.8H_2O$. F. LACHMAN

538.222

1055. Proton resonance in solutions of paramagnetic salts. B. M. KOZYREV AND A. I. RIVKIND. *Zh. éksper. teor. Fiz.*, **27**, *No.* 1, 69–74 (1954) In Russian.

The proton resonance at 10 Mc/s under power saturation conditions is examined and the height of the absorption related to the spin-lattice relaxation time T_1, which in turn is related to the effective moment of the paramagnetic ions in solution by $1/T_1 = 12\pi^2\gamma^2\eta N\mu_{\text{eff}}^2/(5kT)$. For Mn^{++} μ_{eff} is assumed to be 5·90 Bohr magnetons for calibration. In general $\mu_{\text{eff}} < \mu_{\text{stat.}}$ from static susceptibility measurements and the effect is discussed in terms of non-diagonal matrix elements, short spin-lattice relaxation times for the electrons of the paramagnetic ion, and the breakdown of Stokes law especially with non-spherical complex ions. Observed values of μ_{eff} include: $[Cr(H_2O)_6]^{+++}$, 5·10; $[Cr(H_2O)_4SO_4]^+$, 3·5; $[Cu(NH_3)_4]^{++}$, 1·52; $[Fe(H_2O)_6]^{++}$, 5·90; $[Ni(H_2O)_6]^{++}$, 1·30; $[Ni(NH_3)_6]^{++}$, 2·00; and $[Fe(CNS)_x]^{(3-x)+}$, 4·65 to 3·4 Bohr magnetons for NH_4CNS concentration 0·05 to 0·3 mole/litre in the last instance. D. H. WHIFFEN

538.222

1056. Paramagnetic susceptibility of AuCr alloys. A. GIANSOLDATI. *Ark. Fys.*, **8**, *Paper* 12, 151–4 (1954).

Gives results of measurements on alloys with 2%–20% Cr (atomic) at temperatures between 300° and 800°K. Inverse susceptibility, temperature curves (corrected for Au diamagnetism) obey the Curie–Weiss law for the lower Cr concentrations, but for Cr concentrations above about 10% they show a gradual transition from one straight line to another at about 500° to 600°K. Effective p_B values are deduced for the different alloys for the different temperature ranges. E. P. WOHLFARTH

538.222

1057. On the theory of paramagnetic resonance in rare earth metals. S. A. AL'TSHULER. *Zh. éksper. teor. Fiz.*, **26**, *No.* 4, 439–46 (1954) In Russian.

A discussion of the number of peaks and g factors to be expected for the electron resonance with Ce, Pr, Eu and Yb in cubic lattices, for Ce, Pr, Nd, Gd, Tb, Dy, Ho and Er in hexagonal lattices and for Sa in a tetragonal lattice. Interatomic distances and other factors influencing the spin-lattice relaxation time for these metals are also discussed. D. H. WHIFFEN

538.222

1058. Paramagnetic resonance absorption in rare earth metals at centimetre wavelengths. S. G. SALIKHOV. *Zh. éksper. teor. Fiz.*, **26**, *No.* 4, 447–53 (1954) In Russian.

Measurements are made with the metal on the

plunger of a short-circuited waveguide at 9378 Mc/s, by measuring the standing wave at a probe in the guide. The results are:

	at 290°K			at 90°K		
	g	δ	τ	g	δ	τ
α–Ce	2·03	1500	2·2	2·00	1250	2·2
β–Ce	1·47	1000		1·45	450	
α–Pr	2·0	750	5·8	2·00	1050	5·8
α–Nd	1·84	1500	5	1·97	1450	5

where δ is the line-width in gauss, τ the spin relaxation time $\times 10^{10}$ secs as obtained from the loss at zero magnetic field. The β-Ce values are obtained from a sample with the α hexagonal lattice and the β cubic lattice present together. D. H. WHIFFEN

538.24

1059. Critical field phenomena in an isotropic paramagnetic crystal. E. AMBLER AND R. P. HUDSON. *Phys. Rev.*, **96**, *No.* 4, 907–11 (*Nov.* 15, 1954).

Measurements have been made of the variation of magnetic moment with applied field, at constant entropy, for a spherically-ground single crystal of chromic methylammonium alum. Steady fields up to 500 oersteds were applied along a cubic axis of the crystal and the differential susceptibility measured ballistically by reversing a field of 1·7 oersteds in the primary of a mutual inductance surrounding the specimen. The total magnetic moment was obtained by integration. At entropies below that of the "Curie point" the differential susceptibility showed a pronounced maximum in a field of about one hundred oersteds. This behaviour is compared with that observed in earlier measurements on the same specimen in transverse fields. The magnetic moment at constant external magnetic field H, plotted as a function of entropy, shows a maximum for small values of H. The locus of these maxima is evidently a transition curve separating regions of paramagnetic and antiferromagnetic behaviour. A.

538.24 : 536.48

1060. Magnetic anisotropy at 0°K. J. R. TESSMAN. *Phys. Rev.*, **96**, *No.* 5, 1192–5 (*Dec.* 1, 1954).

The results of the spin-wave method of Holstein and Primakoff are extended to obtain approximate values for the dependence of the energy of magnetically saturated cubic crystals upon the direction of magnetization. The anisotropy at 0°K is calculated for the cases of dipolar ferromagnetism and exchange ferromagnetism. In a nearest neighbour approximation, the results agree with those obtained by Van Vleck from a treatment of ferromagnetic anisotropy. However, in the case of dipolar interaction, the nearest neighbour approximation is not sufficient and more distant neighbours are included. For dipolar ferromagnetism, the method gives the following results: In a face-centred cubic (f.c.c.) lattice of spins S, the anisotropy constant K_1 is a maximum when there is no external field and is then given by $K_1 = -0{\cdot}11M_0^2/S$, where M_0 is the saturation magnetization. In a body-centred cubic (b.c.c.) lattice, with no external field, $K_1 = -0{\cdot}15M_0^2/S$. An external field must be applied to obtain saturation in a simple cubic (s.c.) lattice; $K_1 = +0{\cdot}43M_0^2/S$ when the external field $H = 0{\cdot}6M_0$. More generally, in the presence of an external field H, then $K_1 = \kappa(M_0^2/S)[(4\pi/3) + H/M_0]^{-1}$, where $\kappa = -0{\cdot}46$ for an f.c.c. lattice, $-0{\cdot}63$ for a b.c.c. lattice and $+2{\cdot}06$ for an s.c. lattice. All values given are for specimens having zero demagnetizing field. A.

538.24 : 548.736.5.

1061. Saturation magnetization and crystal chemistry of ferrimagnetic oxides. II–III. E. W. GORTER. *Philips Res. Rep.*, **9**, *No.* 5, 321–65 (*Oct.*); *No.* 6, 403–43 (*Dec.*, 1954).

For Pt I, see Abstr. 10342 (1954). In a number of mixed-crystal series anomalous σ-T curves have been looked for: these are not found in the systems $Ni_{1+a}Fe^{III}_{2-2a}Ti_aO_4$ and $Ni_{1\cdot5-a}Zn_aFe^{III}Ti_{0\cdot5}O_4$ because of the unexpected presence of Ti^{4+} ions in tetrahedral sites, proved for $Ni_{1\cdot5}Fe^{III}Ti_{0\cdot5}O_4$ by measurements of the effective g-factor. In the system $Li_{0\cdot5}Fe^{III}_{2\cdot5-a}Cr_aO_4$ $(0 < a < 2{\cdot}0)$ the distribution of the Li^+ and Fe^{3+} ions is anomalous as a result of short-range order. The resultant moment remains positive, and only one type of anomalous σ-T curve, viz. that for which the spontaneous magnetization changes sign with temperature, occurs in a wide range of compositions. For $a \leqslant 1{\cdot}25$ the materials belong to group (*a*) (see Pt I). A change of sign of the resultant moment does occur in the system $NiFe^{III}_{2-a}Al_aO_4$. Anomalous σ-T curves are here found in a narrow range of compositions, but not all types predicted by Néel: the reasons are discussed. The presence of Mn^{2+} ions apparently promotes the formation of angles between the ionic moments in B sites: the complete system $MnFe^{III}_{2-a}Cr_aO_4$ belongs to group (*b*), as well as $MnFe_2O_4$ prepared by other authors and part of the system $Ni_{1\cdot5-a}Mn_aFe^{III}Ti_{0\cdot5}O_4$. In the first-named system *m* probably changes sign only as a result of these angles. A.

ELECTROMAGNETISM . ELECTRODYNAMICS
538.3/.5

538.3

1062. On the propagation of signals in nonlinear electrodynamics. D. I. BLOKHINTSEV AND V. V. ORLOV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 5(11) 513–26 (1953) In Russian.

An analysis of certain general properties of the mathematical apparatus of nonlinear electrodynamics, connected with the propagation of signals. The starting point is the electromagnetic field equations (based on a general Lagrangean L not assumed to be linear in E^2 and H^2) in which derivatives of L up to the second with respect to E^2 and H^2 appear explicitly. The resulting propagation of a signal depends on the values of the fields and leads in general to the existence of four signal velocities which can be both smaller and greater than c, and to the appearance of shock-waves. This is illustrated in a one-dimensional and a spherically symmetric example, the latter exhibiting the non-Euclidean nature of the metric in the vicinity of a point charge (curvature of a light signal). The Lagrangean of Born and Infeld [*Proc. Roy. Soc.*, **144**, 425 (1934)] appears as a special case of nonlinear electrodynamics in which light velocity is not exceeded. W. J. SWIATECKI

538.3 : 530.12

1063. The singular electromagnetic field. L. MARIOT. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 19, 1189–90 (*Nov.* 8, 1954) In French.

See Abstr. 9395 (1954). The permanence of the field in Riemannian space-time is established.

R. A. NEWING

538.55 : 530.162

1064. Properties of the quantum statistical impedance. J. L. JACKSON AND M. C. YOVITS. *Phys. Rev.*, **96**, *No.* 1, 15–16 (*Oct.* 1, 1954).

The transfer function of a general linear dissipative system, which had previously been derived, is examined. It is shown that its real and imaginary parts satisfy relationships which must be true for general passive systems. Examination of the transfer function at low frequencies gives expressions for the equivalent resistance and capacitance. A.

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.561

1065. Low-frequency plasma oscillations. G. V. GORDEEV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 1(7) 19–23 (1954) In Russian.

Ion movements do not affect plasma oscillations so long as the phase velocity of waves in the plasma > thermal MS velocity of the electrons; in the opposite case ion oscillations play a great part in plasma oscillations. It may be shown that such plasma oscillations are necessarily l.f. oscillations. In contradistinction to Vlasov's theory of l.f. plasma oscillations which was based on the hydrodynamic equations of the plasma, the author uses the kinetic equations to show that the oscillations are damped out in the course of time if there is no external field to sustain them, but that in a constant external field undamped steady oscillations are set up. The further investigation is based on Landau's dispersion equation, assuming a distribution function with constant drift velocity which is called "Langevin function" since such functions were investigated in detail by Langevin. The dispersion equation is then transformed into a more generally useful form (applying to h.f., l.f. oscillations and to the excitation of oscillations by particle beams). It is then applied to an investigation of the stability of the equilibrium state of a plasma consisting of one group each of electrons and ions in Maxwellian velocity distribution, both in the absence and presence of an external field. B. F. KRAUS

538.561

1066. Excitation of plasma oscillations. G. V. GORDEEV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 1(7) 24–8 (1954) In Russian.

The interaction of a plasma with an unmodulated beam of charged particles of homogeneous density and velocity had been considered by Akhiezer and Fainberg on hydrodynamical concepts, the excitation of h.f. oscillations being the main object of their investigations. The present paper investigates the interaction of a plasma with a particle beam originating in the plasma itself under the effect of an external electric field, considering the thermal dispersion of the particles of the beam, and showing that the state of a system with undamped plasma oscillations (h.f. as well as l.f.) is stable. In the absence of an external field the beam is dispersed and the system returns to the equilibrium state of the plasma. The treatment is based on the dispersion equation derived in the preceding paper (preceding abstract). The co-ordinate system is so chosen that the drift velocity of the electrons becomes zero. This restriction is later lifted. It is then found that in the case of l.f. oscillations the presence of a beam of charged particles introduces an additional disturbance reinforcing the excitation of the oscillations set up by the electron drift in the external field. The waves produced may have a phase velocity < thermal velocity of the ions of the plasma. The energy source of the oscillations is the energy of the electrons of the plasma and of the ions of the beam, whose drift velocity is thereby reduced. From a certain value this process becomes reversible, i.e. an excessive reduction of the drift velocity increases the damping of the oscillations and leads to a certain return of energy to the beam, this again increasing the drift velocity of the particles. The thermal losses of oscillation energy are replaced by the field. This mechanism maintains the stability of l.f. oscillations of a plasma whose phase velocity < thermal velocity of the ions. B. F. KRAUS

538.566

1067. Phase, group, and signal velocity. J. WEBER. *Amer. J. Phys.*, **22**, *No.* 9, 618–20 (*Dec.*, 1954).

These are defined. Simple examples are given in which the phase and group velocities exceed the velocity of light, in which the phase velocity is a function of distance, and in which the group velocity is equal to the signal velocity. A.

538.566

1068. On the scalar diffraction by a circular aperture in an infinite plane screen. A. T. DE HOOP. *Appl. sci. Res. B*, **4**, *No.* 3, 151–60 (1954).

If Levine and Schwinger's variational formulation of the diffraction of a plane wave by an aperture in an infinite plane screen is applied to the case where the aperture is a circular hole, the problem of finding the aperture distribution can be reduced to the solution of an infinite system of linear equations. As pointed out by Bouwkamp the most appropriate expansion of the aperture distribution is of the form $\Phi_4(\rho) = \sum_{n=0}^{\infty} b_n P_{2n+1}[(1 - \rho^2/a^2)^{\frac{1}{2}}]$, where a = radius of the aperture. In the present paper the system of equations in b_n is investigated. A.

538.566

1069. Statistics of electromagnetic radiation scattered by a turbulent medium. R. A. SILVERMAN AND M. BALSER. *Phys. Rev.*, **96**, *No.* 3, 560–3 (*Nov.* 1, 1954).

The theory of Villars and Weisskopf is used to calculate the univariate and bivariate amplitude distributions of electromagnetic radiation scattered from turbulent fluctuations. The univariate distribution is Rayleigh, and is in excellent agreement with measurements made on a 49·6 Mc/s ionospheric scatter link.

Using the bivariate distribution, the authors relate the amplitude correlation function to a velocity correlation function which appears in the von Weizsäcker–Heisenberg statistical theory of turbulence. In this way the theoretical velocity correlation can be compared with experiment. A.

538.566

1070. Reflection of waves by an inhomogeneous medium. V. A. Bailey. *Phys. Rev.*, **96**, *No.* 4, 865–8 (*Nov.* 15, 1954).

A new approximate solution is given for the general linear second-order differential equation which is especially appropriate in treating the reflection of waves by an inhomogeneous medium. The well-known approximations to a fundamental pair of solutions made by Liouville, Rayleigh and Jeffreys, which suffer from singularities at the zeros of a particular function, are replaced by another pair of simple approximations u_1, u_2, which in general agree well with the first pair but remain finite at the zeros. Then a corresponding approximation ρ_1 is obtained for ρ, the coefficient of reflection of plane waves by a specified inhomogeneous medium. Also iterative processes are given which from ρ_1 (or any other approximation) derive a sequence of approximations ρ_2, ρ_3, . . . , which rapidly converge on ρ. Lastly it is shown that the approximation u_1 for a particular equation leads to a good, simple approximation to the Hankel function $H_n^{(2)}(nz)$ which agrees well with the approximations of Hankel, Debye and Carlini but has a wider range of validity. A.

538.566

1071. On the radiation pattern of a paraboloid of revolution. J. P. Schouten and B. J. Beukelman. *Appl. sci. Res. B*, **4**, *No.* 3, 137–50 (1954).

The radiation pattern of a paraboloid of revolution is determined by using the mathematical form of Huygens' principle where the field intensities in a given domain are expressed in their tangential components on the boundary. These tangential components are supposed to have the values which follow from the reflection of a plane wave at an infinite metal plate, coinciding with the tangent plane to the surface of the paraboloid. Expressions involving infinite series of Bessel functions are obtained which give the intensities of the distant field when an electric dipole is placed at the focus. Approximations are made for the main lobe in the planes perpendicular to and through the dipole. Finally, Zuhrt's method leads to the same results as the approximations given in the present paper. A.

MOLECULAR AND ATOMIC STRUCTURE 539.1

THEORY OF SOLID STATE 539.11

539.11

1072. A quantum mechanical investigation of the binding energy of the LiH-crystal. S. O. Lundqvist. *Ark. Fys.*, **8**, *Paper* 17, 177–96 (1954).

The binding energy has been computed, using a wave-function constructed from the one-electron wave-functions of the free ions. The approximations in the earlier treatments of ionic crystals have been investigated, and it was found that some neglections in the earlier papers seem to be justified, but a certain approximation used in a number of theoretical investigations of molecules and crystals must be considered inadmissible unless only a rough estimate of the binding energy is desired. The free ion orbital approach cannot be justified to the same extent here as in certain other crystals, e.g. NaCl, as the deformation of the diffuse hydrogen ions in the field of the crystal must be expected to be considerable. The total energy was minimized with respect to the effective nuclear charge of the hydrogen ion. The effective nuclear charge for hydrogen ions in the lattice was nearly the same as for free ions and the corresponding value of the cohesive energy was −205 kcal/mol to be compared with the experimental value −217 ± 7 kcal/mol. A.

539.11

1073. The surface energy of sodium. A. B. Scott. *Phil. Mag.*, **45**, 1173–6 (*Nov.*, 1954).

The surface energy of sodium, calculated by the use of the free-electron model, is modified by considering the increased electrostatic energy in the surface if the positive charge is assumed to be localized in the planes of the atomic nuclei instead of distributed uniformly. While the theoretical surface energy is increased significantly, the theory does not yet account for the energy observed experimentally. A.

539.11

1074. The physical nature of a metal surface in conduction theory. H. A. Müser. *Phil. Mag.*, **45**, 1237–46 (*Dec.*, 1954).

A metal electron striking the surface of the metal from inside will be reflected into the metal. This process of reflection is treated as a phenomenon of electron diffraction. The atoms in a metal surface form a regular array, and this array may be considered as a cross-grating. As all free electrons in a metal have practically the same (Fermi) energy, their wavelength is uniform, and the ratio between this wavelength and the cube-edge of a face- or body-centred cubic lattice can be calculated. This gives a relation between the electron wavelength and the dimensions of the cross-grating, and formulae for the distribution of intensity over the various orders of diffraction can be derived. The main result is that the specular reflection is generally suppressed over a wide range of angles of incidence. This is true for any angle between the crystal axes and the surface. Generally most of the intensity is deflected to the first order of diffraction, but in the case of glancing electrons (i.e. electrons striking the surface at very small angles) most of the reflected intensity is found at a direction almost perpendicular to the surface. A.

539.11

1075. Self trapped electrons in a Fermi gas. J. S. Plaskett. *Phil. Mag.*, **45**, 1255–71 (*Dec.*, 1954).

It is shown that Hartree's equations for the negative hydrogen ion have several solutions, the usual one of which does not minimize the energy. This non-uniqueness is also shown to exist for a Fermi gas

where the usual plane waves of the Sommerfeld model do not even give a stationary value for the energy. The energy of the gas can be lowered, by describing some of the electrons by wave-functions that decrease exponentially. The energy is lowered by about 1 eV per electron of this type. If the electron density is sufficiently low (band-width $E < 0{\cdot}5$ eV) all the electrons can be so trapped and the metal becomes an insulator; this provides an *a priori* reason for Mott's rejection of the Bloch wave-functions for nickel oxide. For higher electron densities it is possible to trap a fraction of the electrons, so saving considerable energy; this is compared with Wigner's correlation energy. It is suggested that Friedel, in his explanation of the fine structure of an X-ray absorption edge, has used several solutions of Hartree's (or Fock's) equations that correspond to only one exact excited wave-function, so invalidating his explanation of this effect. A.

539.11

1076. The electrical and thermal conductivities of monovalent metals. J. M. ZIMAN. *Proc. Roy. Soc. A*, **226**, 436–54 (*Dec.* 7, 1954).

The scattering of electrons by the thermal lattice vibrations is considered. The original Bloch theory is qualitatively in agreement with experiment, but has been shown by various authors to be unrealistic in its detailed assumptions. In particular, it ignores Umklapp processes, neglects the difference between longitudinal and transverse phonon velocities and treats electron-phonon interaction as if it were independent of the scattering angle. The Bloch theory is generalized to take account of these effects, and formulae are obtained for the transport properties. Numerical calculations for the case of sodium, using the Bardeen formula for the scattering cross-section and Blackman's value for a "longitudinal Debye temperature," agree better with observation than do the simple Bloch expressions, but there still remain discrepancies. An alternative description of these is to treat the differential scattering cross-section, which is not really known exactly, as if it were an unknown function to be determined. The observed electrical and thermal conductivities of sodium are consistent with a cross-section which has a narrower forward lobe than the Bardeen formula, but does not become so small for scattering in the backward direction. A.

539.11

1077. Interaction of conduction electrons and nuclear magnetic moments in metallic lithium. W. KOHN. *Phys. Rev.*, **96**, *No.* 3, 590–2 (*Nov.* 1, 1954).

The probability density at the nucleus of a metallic lithium conduction electron on the Fermi surface is calculated in the spherical approximation, giving the value $P_F = 0{\cdot}11 \pm 0{\cdot}01$ atomic units. This is in good agreement with measurements of the nuclear magnetic resonance shift discovered by Knight and with recent determinations by Schumacher, Carver and Slichter of the paramagnetic susceptibility. A.

539.11 : 537.531 : 535.42

1078. The characteristic temperature of platinum from X-ray reflections. K. ALEXOPOULOS AND P. EUTHYMIOU. *Phil. Mag.*, **45**, 1332–42 (*Dec.*, 1954).

The characteristic temperature θ of solids is generally derived from measurements of the specific heat. It can also be derived from the temperature factor of the diffraction of X-rays. The first method gives uncertain results in the case of the transition metals, because in these the electronic heat constitutes a considerable part of the total specific heat, and therefore corrections have to be made in order to obtain the specific heat due to the lattice vibrations alone. In the present paper the intensity of the Debye–Scherrer lines diffracted from platinum were determined at different temperatures. The gradual change of the ratio of intensities of two lines gives the desired value of θ. The intensity of the diffraction lines was determined from the density of blackening on a photographic film. The temperatures were determined from the expansion of the lattice constant. Exposures were made at 13 different temperatures between 298° and 1133°K. From the ratio of the integrated intensities of Debye–Scherrer lines (111) and (311) a value of $\theta = 152 \pm 9°$ results. From the pair of lines (200) and (311) the more uncertain value of $192 \pm 29°$ resulted. The weighted mean of the two measurements after taking systematic errors in consideration gives $156 \pm 26°$. These results can be compared to values of θ from specific heat measurements. In the T^3 range specific heat measurements give $\theta = 233°$. At higher temperatures the thermal measurements have to be corrected for electronic heat. Accepting for the degeneration temperature $T_0 = 1750°$K and for the number of electrons $q = 0{\cdot}18$, values around $\theta = 235°$K result. The θ values from X-ray diffraction are thus decidedly lower than the thermal values. The same disagreement has been observed with the metals Li and Na. A.

MOLECULES 539.13

539.13

1079. Recent problems of molecular physics. G. CARERI. *Nuovo Cimento Suppl.*, **12**, *No.* 1, 31–4 (1954) In Italian.

A discussion of some current theoretical approximations.

539.13 : 533.7

1080. The theory of collisions between two diatomic molecules. K. TAKAYANAGI. *Progr. theor. Phys.*, **11**, *No.* 6, 557–94 (*June*, 1954).

The general features of the elastic and the inelastic collisions have been investigated. The inelastic collisions are confined to rotational and vibrational, and the electronic degrees of freedom are disregarded throughout. Starting from the fundamental set of equations for the collision problem, the effects of the non-spherical character of the intermolecular potential are discussed. For the rotational transitions where the level spacings are rather small, the semi-classical method is employed and for the vibrational transitions, the distorted wave method is developed and some simple methods of estimating the cross-sections are also discussed. Special consideration is also given to the cases in which the two colliding molecules are identical. A.

539.13 : 533.7 : 532.7

On a kinetic theory of systems of interacting particles. *See Abstr.* 780

539.132

1081. The symmetry group of an isotropic oscillator. YU. N. DEMKOV. Letter in *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 757 (1954) In Russian.

An operator ϕ_K corresponding to the transformation $x \rightarrow p_x$, $p_x \rightarrow -x$ in classical mechanics is discussed. The operator H commutes with ϕ_K; owing to spherical symmetry a set of unitary operators ϕ_n exists, commuting with H, which represent a continuous Fourier transformation along the axis. The operators, and their derivatives, form, with the operators of the rotation group, the desired group ϕ. It is shown that the types of energy levels are determined completely by ϕ. The 9 infinitesimal elements of ϕ are easy to find; they are conveniently replaced by a tensor operator. J. JACOBS

539.132

1082. The rotational constants of nitrous oxide. M. T. CHRISTENSEN AND H. W. THOMPSON. *Trans Faraday Soc.*, **50**, *Pt* 10, 1027–30 (*Oct.*, 1954).

The vibration rotation band associated with absorption of the fundamental bending vibration of nitrous oxide has been remeasured and previous results have been extended. Values for rotational constants and for the band origin have been derived. The values for α_1, α_2 and α_3 have been discussed in relation to other data now available for this molecule. A.

539.132

1083. Frequency assignments for normal aliphatic compounds. I. The normal paraffins in the range 1450 cm^{-1} to 650 cm^{-1}. H. TSCHAMLER. *J. chem. Phys.*, **22**, *No.* 11, 1845–54 (*Nov.*, 1954).

It is assumed that the normal aliphatic hydrocarbons in their crystalline forms belong to the symmetry groups C_{2v} (odd number of carbon atoms) or C_{2h} (even number of carbon atoms), and that the selection rules for these symmetry groups hold exactly. It is then possible to work out a "theoretical distribution pattern" for the carbon-stretching modes, and for most types of the hydrogen deformation modes. Comparison of these patterns with available experimental data leads to a complete assignment of frequencies of these types in all the normal hydrocarbons for which data are available, and accounts satisfactorily for all spectral features for these materials in the solid and liquid state. The results might evidently be extended to other aliphatic series. A.

539.132 : 535.343.2–15

Infrared spectra of CH_3COONa and CD_3COONa and assignments of vibrational frequencies. *See Abstr.* 844

539.132

1084. Magnitudes of barriers in intramolecular rotation. N. W. LUFT. *J. chem. Phys.*, **22**, *No.* 11, 1814–20 (*Nov.*, 1954).

By applying symmetry considerations to intramolecular torsional barriers the over-all barriers are resolved into contributions from the interactions of individual change distributions (i and k). This makes it possible to classify internal potential barriers and calculate their heights and shapes if the Fourier coefficients C_v^{ik} are known. Some figures, mainly C_3^{ik} values, were obtained from experimental barriers, others can be estimated by theoretical methods. The Lennard–Jones potential with $n = 12$ and $m = 6$ appears to be altogether unsuitable for describing barriers of internal rotation, but a simple repulsive potential $V = a_n R^{-n}$ with $n \sim 5$ furnishes a reasonable approximation. A.

539.132

1085. Rotational spectra of RbCl by the molecular beam electric resonance method. J. W. TRISCHKA AND R. BRAUNSTEIN. *Phys. Rev.*, **96**, *No.* 4, 968–72 (*Nov.* 15, 1954).

The rotational transitions for which $J = 0 \rightarrow 1$ were studied by the molecular beam electric resonance method for the first three vibrational states, $v = 0$, 1, 2, of $Rb^{85}Cl^{35}$ and the ground vibrational state, $v = 0$, of $Rb^{87}Cl^{35}$. The molecular constants of $Rb^{85}Cl^{35}$ and $Rb^{87}Cl^{35}$, and the quadrupole (eqQ) and spin-rotation (c) interaction constants of $Rb^{85}Cl^{35}$ are listed, and the value of $(eqQ)_{Rb}$ for the $v = 0$ state of $Rb^{87}Cl^{35}$ is given. The ratio of the Rb quadrupole moments is $Q_{85}/Q_{87} = 2{\cdot}0669 \pm 0{\cdot}0005$. The mass ratio of the Rb isotopes is $M_{85}/M_{87} = 0{\cdot}9770163 \pm 0{\cdot}0000045$. A.

539.132

1086. Internal rotation in dimethyl acetylene. I. M. MILLS AND H. W. THOMPSON. *Proc. Roy. Soc. A*, **226**, 306–14 (*Nov.* 23, 1954).

The vibrational spectrum of dimethyl acetylene has been remeasured with better resolving power than hitherto, and the rotational fine structure of some perpendicular type bands has been partly analysed. The energy levels of a molecule of this kind in which internal rotation of methyl groups may arise have been re-examined theoretically and the rotational structure of the absorption bands has been more clearly defined than previously. The experimental results are consistent with the assumption of unrestricted internal rotation of the methyl groups, and the Coriolis factors ζ_t for several vibrations have been determined. A.

539.132 : 535.343

1087. Vibration spectra of aromatic compounds. I. Evaluation and interpretation of vibration spectra of benzene and deuterobenzenes (planar vibrations). M. A. KOVNER. *Zh. éksper, teor. Fiz.*, **26**, *No.* 5, 598–608 (1954) In Russian.

On the basis of the work of M. V. Volkenshtein, M. A. Elyashevich and B. I. Stepanov: Molecular Vibrations, GTTI, 1949, the force constants for symmetry co-ordinates and the action coefficients for benzene were determined. Calculated vibration frequencies are in very good agreement with experimental data. An interpretation of the form of vibrations, and of the influence of isotope substitution, is also given. J. JACOBS

539.132 : 535.343

1088. Vibration spectra of aromatic compounds. II. Evaluation and interpretation of the vibration spectra of toluene. M. A. KOVNER. *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 704–13 (1954) In Russian.

Using kinematic coefficients of C_6H_6 and CH_3 the symmetric vibrations are evaluated. An interpretation

of the fundamental and compound frequencies is given, which are observed in combination-scattering and infrared spectra. A list of non-planar and anti-symmetric vibrations of C_6H_6, C_6H_5D and $C_6H_5CH_3$ is added. J. JACOBS

539.132

1089. The electrostatic calculation of molecular energies. I. Methods of calculating molecular energies. A. C. HURLEY. *Proc. Roy. Soc. A*, **226**, 170–8 (*Nov.* 9, 1954).

The calculation of molecular energies from assumed approximate wave-functions is discussed. It is shown that the conventional method, based on the Hamiltonian integral, is but one of several possible approximations, and that two other methods, the virial method and the electrostatic method, avoid the most serious difficulties encountered in a conventional calculation. The mathematical simplicity of the new methods makes them especially suitable for non-empirical calculations on complex systems. The electrostatic method is exemplified by detailed calculations on various electronic states of the hydrogen molecule and the hydrogen molecular ion. A.

539.132

1090. The electrostatic calculation of molecular energies. II. Approximate wave functions and the electrostatic method. A. C. HURLEY. *Proc. Roy. Soc. A*, **226**, 179–92 (*Nov.* 9, 1954).

The electrostatic method of calculating molecular energies introduced in Pt I is investigated more closely. It is shown that, for wave-functions obtained by a consistent application of the Ritz variational procedure (floating functions), the electrostatic method is equivalent to the conventional method in terms of the Hamiltonian integral. Such floating functions are used to investigate various electronic states of the hydrogen molecule and the hydrogen molecular ion, and to explain certain anomalies in previous calculations. A method for estimating charge densities in localized chemical bonds is outlined. A.

539.132

1091. The electrostatic calculation of molecular energies. III. The binding energies of saturated molecules. A. C. HURLEY. *Proc. Roy. Soc. A*, **226**, 193–205 (*Nov.* 9, 1954).

A technique for calculating the binding energy of any saturated molecule is developed. The method is based on an application of the electrostatic theorem, discussed in Pt I and II, to paired-electron orbital wave-functions. These wave-functions include both molecular-orbital and valence-bond functions as special cases. The resulting numerical computations are sufficiently simple to be carried through without approximation even for complex molecules. The method is applied to the lithium molecule and the lithium hydride molecule, and yields results in good agreement with experiment. The choice of wave-functions for calculations on other molecules is discussed. A.

539.132

1092. Chlorine pure quadrupole spectra in some solid compounds. K. TORIZUKA. Note in *J. Phys. Soc. Japan*, **9**, *No.* 4, 645–6 (*July–Aug.*, 1954).

Values are reported for the Cl resonance frequencies in $CCl_3CH(OH)(OCH_3)$, $CCl_3CH(OH)(OC_2H_5)$, $Ba(ClO_3)_2$ and 1-chloro-2 : 4-dinitrobenzene at 90, 210 and 285°K. D. H. WHIFFEN

539.132

1093. Quadrupole resonance of Br^{79} and Br^{81} in para-dibromobenzene. D. DAUTREPPE AND A. BLAISE. *C.R. Acad. Sci. [Paris]* **239**, *No.* 6, 493–5 (*Aug.* 9, 1954) In French.

The variation of ν with T is not in exact agreement with the theory of Bayer [Abstr. 1170 (1952)]. The Zeeman effect as a function of angle for a single crystal shows the structure of p–$C_6H_4Br_2$ to be the same as that of p–$C_6H_4Cl_2$. D. H. WHIFFEN

539.132

1094. Nuclear magnetic resonance spectra and structure of borohydride ion and diborane. R. A. OGG, JR. *J. chem. Phys.*, **22**, *No.* 11, 1933–5 (*Nov.*, 1954).

High resolution proton magnetic resonance spectra are presented for aqueous $NaBH_4$ and liquid B_2H_6 at 30 and 40 megacycles. B^{11} magnetic resonance spectra at 6 megacycles are presented for these same substances. The details of the spectra constitute powerful confirmation of a tetrahedral model for BH_4^- and a bridge proton model for B_2H_6. The bridge protons in the latter display resonance at higher applied magnetic field than do the terminal protons, suggesting a more hydride-ion like character for the former. Quantitative spin-spin multiplet separations and chemical shifts are recorded. A.

539.132

1095. Zeeman splitting of nuclear quadrupole resonances. C. DEAN. *Phys. Rev.*, **96**, *No.* 4, 1053–9 (*Nov.* 15, 1954).

The theory of the Zeeman splitting of the pure quadrupole energy levels for nuclei of half-integral spin is given in a form that is correct for any electric field gradient. The splitting of the spectra is discussed, and also the simplifications that can be made in the theory when the magnetic field is parallel to any of the three principal axes of the electric field gradient. For spin $\frac{3}{2}$ it is shown that the deviation of the gradient from cylindrical symmetry can be determined from the Zeeman spectrum, and detailed calculations are given for this case, along with a discussion of their experimental application. A.

539.132

1096. Nuclear resonance of Nb^{93} in $KNbO_3$. R. M. COTTS AND W. D. KNIGHT. *Phys. Rev.*, **96**, *No.* 5, 1285–93 (*Dec.* 1, 1954).

The nuclear resonance of Nb^{93} in a single crystal of $KNbO_3$ has been studied in magnetic fields of approximately 5000, 100 and zero oersteds, and at temperatures between −196°C and +460°C. The quadrupole splitting of the magnetic resonance line in strong fields is found to be a sensitive function of crystal structure and, hence, of temperature. Temperatures of the phase transitions found in this way at about −50, +220 and +430°C are in agreement with other known data for this substance. The splitting $\Delta\nu$ of one satellite line is a continuous function of temperature between 220 and 430°C; near 430°C $\Delta\nu$ changes abruptly, indicating a first-order phase change.

Below the Curie temperature (430°c) $KNbO_3$ is ferroelectric, with noncubic crystal structure. Above 430° it is cubic and a single resonance line is observed. Four lines have been identified in the pure quadrupole spectrum in zero magnetic field, and at 20°c. From the four frequencies the quadrupole coupling and asymmetry parameter are evaluated to be 23·1 Mc/s and 0·80, respectively. At −196°c, the frequencies are different from the room temperature values, and the quadrupole coupling is evaluated to be 16·0 Mc/s and the asymmetry parameter 0·0, the latter appropriate to the rhombohedral crystal structure at this temperature. The Zeeman effect in magnetic fields up to about 100 oersteds is shown to be an aid in identifying the absorption lines and in locating the principal axes of the crystalline electric field gradient. The value of the quadrupole coupling constant is consistent with the existence of a strong covalent character in the chemical bonding to the Nb. A.

539.132

1097. Nuclear quadrupole spectra in solids. M. H. COHEN. *Phys. Rev.*, **96**, *No.* 5, 1278–84 (*Dec.* 1, 1954).

Numerical values for the energy levels, Zeeman splitting parameters and intensity parameters of the pure quadrupole spectrum are given for ten values of the asymmetry parameter for spins $\frac{5}{2}$, $\frac{7}{2}$ and $\frac{9}{2}$. The intensity parameters for the $m \rightarrow -m$ transition in a magnetic field for large asymmetric quadrupole interaction are given. They show that the corresponding lines should be observable. A method of increasing the accuracy of perturbation calculations is presented for the Zeeman splitting case and the strong magnetic field case. A.

539.132

1098. Molecular orbital theory and the reactivity of polyphenyls. S. BASU. *Indian J. Phys.*, **28**, *No.* 7, 319–24 (*July*, 1954).

Resonance energies, electronic transitions and π-electron densities have been calculated by LCAO MO methods for polyphenyls. The electron densities have been correlated with the chemical reactivities of these compounds at different positions of the ring. Possibility of using frontier electron density instead of π-electron density has also been indicated. A.

539.132

1099. Theoretical calculation of shifts in substituted benzenes. S. RAMAMURTY. *Indian J. Phys.*, **28**, *No.* 7, 325–8 (*July*, 1954).

Using the MO method of Herzfeld the effect of CH_3 and NH_2 substitutions in benzene in shifting the 0, 0 position of the band system of benzene has been calculated. It is suggested that the inductive effect is also to be taken into account. A.

539.132

1100. The calculation of resonance and localisation energies in aromatic molecules. C. A. COULSON. *J. Chem. Soc.*, **1954**, 3111–15 (*Sept.*).

A simple method is described whereby the π-electron resonance energy of an aromatic or conjugated molecule, and the localization energies required in the discussion of chemical reactivity, may be obtained by means of one single numerical integration, without the need for explicit calculation of any of the energies of the separate molecular orbitals. The overlap integral may be included in these calculations. A.

539.132

1101. The influence of corrections to the monocentric integrals upon the characteristics of a butadiene, calculated by the method of the self-consistent molecular field. A. PULLMAN AND H. BERTHOD. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 14, 812–14 (*Oct.* 4, 1954) In French.

In order to obtain better agreement with experimental spectroscopic results, corrections in accordance with the method of "atoms in molecules" have been made to the monocentric integrals occurring in the elements of the interaction matrix calculated for *s-trans*-butadiene on a basis of self-consistent molecular orbitals. The ground-state energy is lowered by 5·6 eV, and the $N \rightarrow V_1$, $N \rightarrow V_2$ transitions and the singlet-triplet separation for the first excited state are brought nearer to the experimental values. Configuration interaction is reduced for ^1A_g and ^3B_u states, increased for ^1B_u. It is concluded that the self-consistent wave-function is still a useful description of the ground state. A. J. TAYLOR

539.132

1102. Configurational interaction in simple molecular orbital theory. W. MOFFITT. *J. chem. Phys.*, **22**, *No.* 11, 1820–9 (*Nov.*, 1954).

The application of simple MO theory in the interpretation of electronic spectra is investigated. Certain simple theorems are derived and their applications, particularly with respect to configurational interaction in the polyacene series, are discussed. The potentialities and difficulties of this approach are enumerated, and it is concluded that the theory should only be used with caution. A.

539.132

1103. Free-electron network model for conjugated systems. V. Energies and electron distributions in the FE MO model and in the LCAO MO model. K. RUEDENBERG. *J. chem. Phys.*, **22**, *No.* 11, 1878–94 (*Nov.*, 1954).

For Pt IV, see Abstr. 8626 (1953). A comparative study is made of the LCAO MO model (including overlap) and the FE MO model. Energies and electronic distributions are examined and the concepts "atom population" and "bond population" are analysed. A close correspondence is found to exist between the two theories. A.

539.133

1104. General equations for the determination of magnetic susceptibility of molecules without permanent moments. J. TILLIEU AND J. GUY. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 19, 1203–5 (*Nov.* 8, 1954) In French.

The total energy in the presence of a field H is expanded to quadratic terms in the components of H. The expression so obtained indicates that the molecules considered show no paramagnetism of 1st order in H. The susceptibility tensor χ can then be deduced by a method used previously [Abstr. 3781 (1952)]. Its trace reduces to the diamagnetism formula of Langevin for atoms in ^1S states. Hence Langevin's theory remains valid for molecules in the $C_{\infty h}$ or $D_{\infty h}$ symmetry group. J. JACOBS

539.133

1105. Calculation of molecular magnetic susceptibilities and anisotropies as a function of monoelectronic susceptibilities and anisotropies. J. TILLIEU AND J. GUY. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 20, 1283–5 (*Nov.* 15, 1954) In French.

Gives an outline of a method based on molecular orbital theory, the arguments followed being analogous to those proposed for the calculation of electrical polarizabilities (preceding abstract).

G. I. W. LLEWELYN

ATOMS . NUCLEUS . ISOTOPES 539.15

539.152.1

1106. A possibility of checking the nuclear shell model. L. A. SLIV AND L. K. PEKER. Letter in *Zh. éksper. teor. Fiz.*, **25**, *No.* 3(9) 381–3 (1953) In Russian.

The existence of 3 groups of excited nuclei resulting from a slow-neutron capture can be explained by differences in the nature of γ-emission if one knows the spins of the target-nucleus and product-nucleus in the ground state and their parity. The nuclear shell model [cf. Abstr. 6006 (1950)] makes it possible to obtain these data required for the analysis of the γ-transitions. The available experimental data on the nature of γ-transitions in (n, γ) are tabulated. Out of ~30 examples given, only N^{14} is at variance with the authors' explanation. F. LACHMAN

539.152.1

1107. On a statistical theory of the atomic nucleus. II. A. A. SOKOLOV AND B. K. KERIMOV. *Zh. éksper. teor. Fiz.*, **26**, *No.* 4, 430–8 (1954) In Russian.

See Abstr. 8511 (1954). A statistical 1st-order perturbation treatment of the energy of infinitely extended nuclear matter, using a meson-type two-body potential containing central and tensor forces appropriate to 2 meson fields (vector and ps. scalar) of different masses, and coupling strengths chosen to eliminate the r^{-3} singularity in the tensor force. The expression for the total energy per unit volume is integrated out explicitly and the condition for a minimum with respect to change of density is written down. If the masses of the mesons are taken as $265m_e$ the coupling constants deduced from this condition are not much less than 1, and a perturbation treatment is doubtful. If one of the mesons (vector) is $130m_e$, small coupling strengths are sufficient. W. J. SWIATECKI

539.152.1

1108. Frequencies of the capillary and elastic vibrations in an electro-capillary nucleus [nuclear model]. S. G. RŸZHANOV. Letter in *Zh. éksper. teor. Fiz.*, **26**, *No.* 4, 509–10 (1954) In Russian.

In Hill and Wheeler's calculations of the eigenfrequencies of the capillary vibrations of heavy nuclei [Abstr. 3522 (1953)], based on Frenkel's formula, the "nuclear fluid" was assumed to be incompressible. Having allowed for compressibility, the author finds that his assumption results in a reduction of the eigenfrequency of vibrations of the "liquid-drop" nucleus. F. LACHMAN

539.152.1

1109. Statistical calculation of the distribution of density and the shell structure of the nucleus. L. P. RAPOPORT AND V. A. FILIMONOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 2(8) 243–50 (1954) In Russian.

The energy of the nucleus is calculated using an exponential-type potential between nucleons with different exchange characters for *n-p* and *p-p* interactions. Coulomb forces are neglected. The density is then taken as $\rho = \rho_0$, for $r < R_0$ and $\rho = \rho_0 e^{-(r-R_0)^2/R^2}$, for $r > R_0$, and the energy is minimized with respect to the two independent constants occurring here. With the resulting charge density, density of particles with a given angular momentum l can be defined and the number of particles n_l is calculated as a function of number of nucleons. G. E. BROWN

539.152.1

1110. Particle derivation of nuclear rotation properties associated with a surface wave. D. R. INGLIS. *Phys. Rev.*, **96**, *No.* 4, 1059–65 (*Nov.* 15, 1954).

The dynamical conception of nuclear rotation in terms of a surface wave on a droplet of irrotational fluid has achieved some success in spite of the great differences between nucleons and the particles of a normal classical fluid. As a justification for the simplifying assumption of irrotational fluid flow, the collective rotational energy is here derived from a suitable set of nucleon wave-functions in the approximation in which there is a rotating distortion, slow compared with the internal nucleon motions. The wave-functions are those of a three-dimensional harmonic oscillator that is made anisotropic by having the force constant along one axis different from those along the other two in a rotating Cartesian co-ordinate system. For the case of steady rotation about a fixed axis, the perturbation problem with first-order wave-functions leads to a second-order rotational energy which agrees with the droplet-model result. The observed level spacings appear to lie between this result and that of a rigid rotator, and the discrepancy is probably to be attributed to higher orders. The result is also derived by another method without introducing a steady rotation. A.

539.152.1

1111. A new model for nuclear matter. T. H. R. SKYRME. *Proc. Roy. Soc. A*, **226**, 521–30 (*Dec.* 7, 1954).

The different values obtained for nuclear radii from electromagnetic interactions as compared with specifically nuclear interactions suggest a model of nuclear matter in which the meson field is supposed to condense into an incompressible fluid and the nucleonic sources are confined to its interior by a strong interaction between the sources and the fluid as a whole. The sources are also coupled to spin and charge fluctuations in the fluid, whose exchange leads to further internucleonic forces. It is necessary to postulate that the fluid has a comparatively low density; as a result rotational levels of the fluid are high, leading to a small probability of exchange of angular momentum (and charge coupled to it) with the sources. The values of the anomalous electrical interactions of nucleons deduced are in rough agreement with the facts. The nuclear structure indicated is a shell model embedded in the mesic fluid whose

oscillations, strongly coupled to the nucleons, give rise to the collective features of nuclear structure as in the theory of Bohr and Mottelson. It is suggested that this picture of the mesic field may indicate where to look for solutions of the meson field equations. A.

539.152.1 : 539.18

1112. Optical model of nuclei and elastic back-scattering of π-mesons. A. MINGUZZI. *Nuovo Cimento*, **12**, *No.* 5, 799–806 (*Nov.*, 1954).

A general inequality is established connecting the differential elastic cross-section at 90° and 180° in the limiting case of a black nucleus. The optical model of nuclei is applied to the interaction of π-mesons with the heavy elements of Ilford G.5 plates. A.

539.152.1

1113. The levels of nuclei on the basis of experimental indications. M. A. LEVIT-SKAYA. *Zh. éksper. teor. Fiz.*, **27**, *No.* 1(7) 29–38 (1954) In Russian.

An attempt to replace the systematics of the shell model by a grouping of nuclei according to the number of constituent α-particles and unpaired neutrons. W. J. SWIATECKI

539.152.1

1114. Energy levels in $_{66}Dy^{160}$. V. KESHISHIAN, H. W. KRUSE, R. J. KLOTZ AND C. M. FOWLER. *Phys. Rev.*, **96**, *No.* 4, 1050–2 (*Nov.* 15, 1954).

An energy level diagram for $_{66}Dy^{160}$ is proposed which is consistent with most of the experimental data on this activity, as well as with further data reported here. Levels are proposed at 86·2, 282, 496, 962, 1196, 1259, 1352 and 1532 keV. β-spectra of 851 ± 10, 557 ± 15, 461 ± 20 and 280 ± 40 keV have been observed and support the diagram. A.

539.152.1

1115. Neutron-widths and the density of nuclear levels. J. M. C. SCOTT. *Phil. Mag.*, **45**, 1322–31 (*Dec.*, 1954).

The theoretical relation between the level width and the mean spacing D of the levels is investigated, using a model with strong configuration-mixing, not strong enough, however, to destroy the size resonance effect. Rough numerical values of Γ/D are obtained using a previous analysis of the size resonance effect in the thermal-neutron cross-sections. The lack of sharpness of the surface of the nucleus has been taken into account, and is responsible for a factor of two or three in the calculated level widths. A.

539.152.1

1116. Energy levels of Be^{10}. J. J. JUNG AND C. K. BOCKELMAN. *Phys. Rev.*, **96**, *No.* 5, 1353–5 (*Dec.* 1, 1954).

A magnetic spectrograph has been employed to measure the momenta of proton groups emitted at 90 degrees from a thin beryllium target bombarded by deuterons. Groups were observed corresponding to the ground state of Be^{10}, as well as known levels at 3·37, 5·96, 6·26, 7·35 and 7·54 MeV. A new level at 6·18 MeV was also seen. A.

539.152.1

1117. Nuclear orientation of ^{54}Mn. M. A. GRACE, C. E. JOHNSON, N. KURTI, H. R. LEMMER AND F. N. H. ROBINSON. *Phil. Mag.*, **45**, 1192–6 (*Nov.*, 1954).

Orientation of Mn^{54} at very low temperatures has been attained. The anisotropy of the 0·835 MeV γ-radiation emitted in its decay shows that the first excited state of Cr^{54} has spin 2. Detailed interpretation of the results is discussed. A.

539.152.2

1118. On the magnetic moments of doubly odd nuclei. I. A. VAÏSMAN. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9) 386–7 (1954) In Russian.

The magnetic moments are obtained by assuming the protons in addition to the closed shells to form one system, the neutrons to form another, and by adding the moments of these two separate systems. Results agree with experiment about as well as those from *j-j* coupling calculations. G. E. BROWN

539.152.2

1119. Nuclear magnetic octupole moments of the stable gallium isotopes. R. T. DALY, JR AND J. H. HOLLOWAY. Letter in *Phys. Rev.*, **96**, *No.* 3, 539–40 (*Oct.* 15, 1954).

The zero-field hyperfine structure of the metastable $^2P_{3/2}$ state of Ga has been reinvestigated with the Ramsey technique of separated oscillating fields. For Ga^{69} the octupole coupling term is 84 ± 6 c/s and the octupole moment 0·107 ± 0·02 n.m.cm² while for Ga^{71} the values are 115 ± 7 c/s and 0·146 ± 0·02 n.m.cm². D. H. WHIFFEN

539.152.2

1120. The deuteron polarizability and its effect on the Rutherford scattering. J. SAWICKI. Letter in *Acta phys. Polon.*, **13**, *No.* 3, 225–8 (1954).

The effect of polarization can be represented by a perturbing term in the potential, in an approximation to the exact quantum equation. This term has the same form as the term derived by classical arguments [Abstr. 691 (1954)], but a different factor. The equation of the deuteron in the electric field of a nucleus is then solved asymptotically to find the scattering, using various approximations in different regions of energy and angle. G. E. BROWN

539.152.2

1121. Observation of proton resonance between 10 and 50 kc/s. J. WINTER, J. SALMON, C. MANUS, G. BÉNÉ, P. DENIS AND R. EXTERMANN. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 14, 803–4 (*Oct.* 4, 1954) In French.

Description of a Bloch type apparatus with sample of 200 cm³, magnetic field 2–10 gauss, oscilloscope presentation, sweep frequency 50 c/s and a signal-to-noise ratio of 8. D. H. WHIFFEN

539.152.2

1122. Measurement of the spin and gyromagnetic ratio of C^{13} by the collapse of spin-spin splitting. V. ROYDEN. Letter in *Phys. Rev.*, **96**, *No.* 2, 543–4 (*Oct.* 15, 1954).

In $C^{13}H_3I$ the spin of ½ of the C^{13} gives two hyperfine peaks to the H resonance, but if the C^{13} nucleus simultaneously undergoes absorption, the structure is destroyed and its disappearance can be used as a sensitive indicator of the C^{13} resonance. An accuracy of 20 c/s was obtained using signals of 30 Mc/s and 7·5 Mc/s for the H and C^{13} with one sample and coil, the exact ratio ν_C^{13}/ν_H^1 being 0·2514431 ± 0·0000005. D. H. WHIFFEN

539.152.2

1123. Effect of chemical shift and *J*-coupling on nuclear resonance line-shape. M. K. Banerjee, T. P. Das and A. K. Saha. *Proc. Roy. Soc. A*, **226**, 490–509 (*Dec.* 7, 1954).

The splitting up of nuclear resonance lines due to *J*-coupling is dealt with in detail for both the cases $J \sim \delta$ and $J \ll \delta$. It is shown that for $J \sim \delta$, appreciable departures occur from Gutowsky's rule in both the intensities and frequencies of the components, particularly the former. The exact line-patterns in several important cases are given. A.

539.153

1124. On the first electrons with a given *l* in a neutral atom. V. M. Klechkovskiĭ. Letter in *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 760–1 (1954) In Russian.

A new expression for Z_l is derived from an earlier formula [Abstr. 3526 (1953)]; l is the orbital quantum number and Z_l the atomic number of the element for which 1 electron with given l occupies the electron-shell in a neutral non-excited atom. For $l = 0$, 1, 2 agreement is found with experiment; for higher l values complete agreement can be obtained in terms of $2Z_l$. Hence expressions can be obtained representing the structural changes in the electron-shells with increasing Z. J. JACOBS

539.153

1125. Hyperfine structure of nitrogen. M. A. Heald and R. Beringer. *Phys. Rev.*, **96**, *No.* 3, 645–8 (*Nov.* 1, 1954).

The magnetic resonance spectrum of the ^4S ground state of atomic nitrogen-14 has been observed using the microwave absorption method. The magnetic-dipole hyperfine interaction constant is $A = 10{\cdot}45 \pm 0{\cdot}02$ Mc/s. No evidence was obtained for electric quadrupole interaction. A.

539.153

1126. Energy level displacements in pi-mesonic atoms. S. Deser, M. L. Goldberger, K. Baumann and W. Thirring. *Phys. Rev.*, **96**, *No.* 3, 774–6 (*Nov.* 1, 1954).

The energy level shifts and level widths of the s states of the π-mesonic atoms are discussed. The discussion is limited to fairly light nuclei. On the basis of Orear's determination of the scattering lengths for meson-nucleon scattering, semiquantitative predictions are made. It is pointed out that even a knowledge of the algebraic sign of the level shift would be of value. A.

539.153.4 : 536.7

1127. Thermodynamics of the Thomas–Fermi atom at low temperature. J. J. Gilvarry. *Phys. Rev.*, **96**, *No.* 4, 934–43 (*Nov.* 15, 1954).

It is shown that an expression for the Helmholtz function on the Thomas–Fermi atom model permits one, in the limit of low temperature T, to expand the total energy as an asymptotic series in T^2. The leading term of the expansion is a known analytic expression for the energy at $T = 0$, from which one can calculate the pertinent thermodynamic functions for this case in their dependence on the atom radius and on the boundary and initial parameters associated with a solution of the zero-temperature Thomas–Fermi equation. Published values of these parameters are fitted by functions of the atom radius having the correct asymptotic behaviour in the two limiting cases of an infinitesimal and an infinite atom. This procedure makes thermodynamic functions in this case directly available. Thermodynamic functions for the case of a first-order temperature perturbation are derived from the corresponding term in the asymptotic expansion of the energy. They depend (in addition to dependence on parameters of the unperturbed atom) on two parameters derived from solution of the differential perturbation equation. These parameters differ according as the differential perturbation equation is solved under a condition of fixed atomic volume or of zero initial slope (which is computationally more convenient and corresponds to published solutions). The asymptotic forms of the parameters in the first case are determined for the two limits of an infinitesimal and an infinite atom. The boundary and initial parameters corresponding to fixed atomic volume are expressed in terms of the parameters corresponding to a solution under zero initial slope, and are evaluated in three cases from published solutions. These values are fitted by functions of the atom radius which have the proper limiting behaviour for an infinitesimal and an infinite atom. Thus, approximate values of the first-order temperature perturbations of thermodynamic functions become directly available. A.

539.153.4 : 548.735

1128. Some calculations of atomic form factors. J. A. Hoerni and J. A. Ibers. *Acta Cryst.*, **7**, *Pt* 11, 744–6 (*Nov.*, 1954).

X-ray atomic form factors for carbon, nitrogen and oxygen have been computed from Hartree–Fock radial wave-functions, and compared with the values previously obtained by James and Brindley, and McWeeny. A.

539.154.3

1129. Polarizability of atoms and ions with closed shells. A. V. Bravin. *Zh. éksper. teor. Fiz.*, **25**, *No.* 2(8) 147–56 (1953) In Russian.

The variation principle has been used for investigating the polarizability of atoms and ions [cf. *Proc. Cambridge Phil. Soc.*, **26**, 542–55 (*Oct.*, 1930); *Phys. Rev.*, **37**, 682–97 (*March* 15, 1931); *Physikalische Zeitschrift*, **33**, 57–60 (*Jan.* 15, 1932); *Acta Physicochimica*, **2**, *No.* 3, 273–90 (1935)]. It is shown that polarizability values obtained with the aid of formulae in Kirkwood's paper [*Physikalische Zeitschrift*, **33**, 57–60 (*Jan.* 15, 1932)] are too high as a result of the assumption that the unperturbed wave-function exactly satisfies the unperturbed Schrödinger equation. It is shown that, if no such assumption is made, one always obtains lower polarizability values, and a better agreement with experiment for Na^+.

F. LACHMAN

539.154.3

1130. Calculation of the polarizability of some atoms and ions. A. V. Bravin. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9) 384–5 (1954) In Russian.

Results are reported for F^-, Ne, Na^+, Cl^-, A, K^+; the calculations are carried out by the method of the preceding abstract. The results are quite insensitive to the choice of one-electron radial function.

G. E. BROWN

539.154.3

1131. Electronic polarizabilities of ions from the Hartree–Fock wave functions. R. M. STERNHEIMER. *Phys. Rev.*, **96**, *No.* 4, 951–68 (*Nov.* 15, 1954).

The electronic polarizability α has been calculated for several ions by obtaining the perturbation of the wave-functions by an external field from a numerical solution of the differential equation satisfied by the perturbation. For the helium-like ions an analytic solution was obtained by using the wave-functions of Löwden. The calculated values of α are, in general, between 1 and 1·5 times the observed values. For several ions values have been calculated for the quadrupole polarizability which measures the quadrupole moment induced in the ion by an external charge. The effect of the dipole moment induced in the ion on the electric field at the nucleus is discussed. A.

539.155.2

1132. The mass spectrum of titanium tetrachloride. J. E. HOGG. *Canad. J. Chem.*, **32**, *No.* 11, 1039–43 (*Nov.*, 1954).

An investigation of the mass spectrum of titanium tetrachloride prepared from both commercial titanium dioxide and titanium minerals has been carried out, using a 180° Nier-type mass spectrometer. Values for the relative abundances of the titanium and chlorine isotopes have been found. Measurements of the singly ionized trichloride group show that any variation in the relative abundances of the isotopes of titanium contained in these samples must be less than 1%. A.

539.155.2

1133. Variations in the isotopic abundances of neon and argon extracted from radioactive minerals. G. W. WETHERILL. *Phys. Rev.*, **96**, *No.* 3, 679–83 (*Nov.* 1, 1954).

Large excesses of Ne^{21}, Ne^{22} and A^{38} have been found in uranium and thorium minerals. These abnormal abundances are ascribed to (α, n) and (α, p) reactions in the minerals. It is shown that it is possible that a part of the atmospheric Ne^{21} originated in this way. A.

539.155.2

1134. Natural abundance of the lithium isotopes. D. A. HUTCHISON. *Phys. Rev.*, **96**, *No.* 4, 1018–21 (*Nov.* 15, 1954).

The natural abundance ratio of the lithium isotope of mass 7 to the isotope of mass 6 has been determined from the density and X-ray data for certain crystals. Consideration of the maximum limits of variation of this ratio in nature and the error assignments of the data used in this calculation have resulted in the value $11{\cdot}53 \pm 0{\cdot}29$. This value disagrees with the mass spectrometric and optical determinations. Some of the possible errors in the mass spectrometric work are considered. A.

539.155.2 : 537.534.72 : 621.389

1135. The anti-contamination circuit of the Amsterdam isotope separator. I. J. SCHUTTEN, C. J. ZILVERSCHOON AND J. KISTEMAKER. *Appl. sci. Res. B*, **4**, *No.* 3, 217–24 (1954).

A description is given of the circuit to prevent contamination of the collected isotopes in an electromagnetic isotope separator. In some cases the results of days or even weeks can be spoiled in a relatively short time when the material to be separated contains an isotope of low concentration. In order to get the highest purity obtainable with the separator and to avoid continuous observation of meters and instruments, the place and shape of the image in the focusing plane, near the collector, controls an automatic correcting circuit and safeguard system. The signals depending directly on the ion beam are part of: (*a*) the beam shifting control, determining the position of the ion beam in the collector chambers by comparing the current to two electrodes near the collector, (*b*) the beam intensity control, operating the safeguard system by comparing the total current to these electrodes with a reference current, (*c*) the focusing control, also operating the safeguard system by a signal proportional to the fraction of the ion beam, striking a diaphragm before the collector. A.

539.155.2 : 537.534.72 : 621.389

1136. The anti-contamination circuit of the Amsterdam isotope separator. II. J. SCHUTTEN. *Appl. sci. Res. B*, **4**, *No.* 3, 225–34 (1954).

The circuit is operated by the difference of the currents on two needle electrodes in the beam, operating a small servomotor to correct the accelerating voltage until the beam reassumes the correct position (beam shifting control); the total current on these electrodes is compared with an adjustable reference current, and when the difference between these two currents exceeds a certain value, a cover is closed before the collector (intensity control); the current on a diaphragm before the collector is integrated over periods of 30 sec. At too large a value of this time integral the cover is also closed. A.

539.155.4

1137. Certain rules and the calculation of the masses of atoms. G. P. MAÏTAK. *Zh. éksper. teor. Fiz.*, **27**, *No.* 1, 39–43 (1954) In Russian.

The masses of 155 isotopes are fitted by 2 formulae (for even and odd Z) linear in Z and $N - Z$. The deviations $\Delta M/M$ are of the order of 0·005–0·05% (up to 0·3% for light nuclei). W. J. SWIATECKI

RADIOACTIVITY . α-, β- AND γ-RAYS 539.16

539.16.08

1138. Absolute counting of α-particles and neutrons with a scintillation counter. B. GRIMELAND. *JENER Rep.*, *No.* 30, 11 *pp.* (1954).

Uranyl nitrate was dissolved in a mixture of water and alcohol, a small amount of the solution was mixed with ZnS(Ag) on an aluminium foil, and the liquid evaporated. If this sample is placed on the photocathode of a photomultiplier tube, an absolute counting of the α-particles can be carried out. The accuracy is 5% or better. The sample can also be used as a neutron detector. Other neutron detectors examined were samples consisting of boric acid or lithium chloride, both mixed with zinc sulphide. The results obtained with the boron detectors were not too convincing. With the lithium detectors,

neutron densities can be measured with an accuracy of 10% or better. Measurements were made to compare the absorption cross-sections of boron and lithium and the fission cross-section of U^{235} with the activation cross-section of sodium. The results indicate that the activation cross-section of sodium should be equal to its absorption cross-section, that is to 0·5 barn. A.

539.16.08

1139. Experimental determination of the gram-roentgen in ergs. K. G. TSIMMER. *Zh. éksper. teor. Fiz.*, **26**, *No.* 3, 367–9 (1954) In Russian.

By placing a source of radiation inside a large absorber and measuring the dose at various distances with an ionization chamber the integral dose can be deduced and, from the known energies of the disintegration, the conversion factor of ergs to gram-roentgens. With a Co^{60} source in 4 m^3 of water the result was 84 erg g^{-1} r^{-1}. W. J. SWIATECKI

539.16.08

1140. Trends in nuclear instrumentation. D. TAYLOR. *Nucleonics*, **12**, *No.* 10, 12–19 (*Oct.*, 1954).

Short summaries of papers presented at a tripartite conference (Canada, U.S., U.K.) held at Harwell in May, 1954. The subjects include a discussion of the statistics of electronic component failure, portable radiation monitoring equipment, pulse-height analysers, scintillation counters, quick indication airborne α-activity mohitors, transistor circuits and an automatic reactor start-up control system. L. R. SHEPHERD

539.16.08 : 778.34

1141. Film badge dosimetry: How much fading occurs? W. L. MCLAUGHLIN AND M. EHRLICH. *Nucleonics*, **12**, *No.* 10, 34–6 (*Oct.*, 1954).

The instability of the latent image in photographic emulsions is discussed. Six different commercial emulsions were exposed to 150 keV X-rays and the diffuse transmission densities of the developed emulsions were measured for various intervals (up to eight days) between exposure and development. Empirical expressions giving fading as a function of storage time were derived from the results for each emulsion. L. R. SHEPHERD

539.162

1142. Orbital electron capture in the heaviest elements. R. W. HOFF AND S. G. THOMPSON. *Phys. Rev.*, **96**, *No.* 5, 1350–2 (*Dec.* 1, 1954).

Log *ft* values have been calculated for 30 orbital electron capture isotopes in the heaviest elements ($Z = 89$–97). The average values of log *ft* products for negative β-particle transitions have been used to classify the electron capture transitions studied as to forbiddenness. A logarithmic plot of the electron capture partial half-life *v.* neutrino energy has been made for both the allowed and forbidden species. These diagrams can be used in the prediction of electron capture half-lives where one has some insight into the amount of decay energy available. A.

539.163

1143. A search for natural radioactivity in neodymium, rhenium and osmium. D. DIXON AND A. MCNAIR. *Phil. Mag.*, **45**, 1099–108 (*Nov.*, 1954).

The element neodymium and the naturally occurring isobaric pair rhenium 187 and osmium 187 are investigated, as internally mounted sources in a well-shielded proportional counter, for evidence of natural radioactivity. The β-decay probability of neodymium 150 corresponds to a half-life of not less than 10^{16} yr. No β instability of rhenium is observed and 10^{15} yr is suggested as the minimum possible half-life for the isotope Re^{187}. The emission of *L* X-rays from osmium is observed, but it is found that dense materials show similar emission, and it is attributed to the photoelectric absorption of γ-rays (residual background) in the materials. It is concluded that there is no evidence of decay in osmium and the estimated minimum possible half-life by electron capture exceeds 10^{15} yr. A.

539.163

1144. Short-lived radio-nuclides produced by a synchrocyclotron. H. TYRÉN AND P.-A. TOVE. *Phys. Rev.*, **96**, *No.* 3, 773–4 (*Nov.* 1, 1954).

A method of studying short-lived radio-nuclides produced by the internal beam in a synchrocyclotron is described. Preliminary results on a number of proton-produced activities in the mass range below 70 are given. A.

539.163.1

1145. Calorimetric determination of the half-life of polonium-210. J. F. EICHELBERGER, K. C. JORDAN, S. R. ORR AND J. R. PARKS. *Phys. Rev.*, **96**, *No.* 3, 719–21 (*Nov.* 1, 1954).

Six determinations have been made of the half-life of polonium with four different steady-state, resistance-bridge calorimeters and five different samples of polonium. These six values of the half-life have been weighted and combined to give a grand-mean value of the half-life of 138·4005 ± 0·0051 days (internal consistency) or ±0·0058 day (external consistency). A.

539.163.2

1146. Neutron-deficient activities of praseodymium. T. H. HANDLEY AND E. L. OLSON. *Phys. Rev.*, **96**, *No.* 4, 1003–5 (*Nov.* 15, 1954).

Neutron-deficient radionuclides of praseodymium were produced by proton bombardment of enriched isotopes of cerium and neodymium. Two unreported activities were found, 22 min Pr^{135} and 70 min Pr^{136}; the γ and β spectra of each were determined. Further study of 2·0 hr Pr^{138} and 4·5 hr Pr^{139} was also made, and γ-spectra of each are shown. The half-life of Pr^{137} is shown to be <5 min or >1 year. Confirmation of assignment of 3·4 min Pr^{140} is made. A.

539.163.2

1147. Decay of UX_1, UX_2, and UZ. S. A. E. JOHANSSON. *Phys. Rev.*, **96**, *No.* 4, 1075–80 (*Nov.* 15, 1954).

The decay of $Th^{234}(UX_1)$ and $Pa^{234}(UX_2$ and UZ) has been investigated by means of a coincidence scintillation spectrometer. Three γ-rays at 29, 63 and 92 keV were found in UX_1. Four γ-rays at 250, 750, 1000 and 1810 keV were found in UX_2, and four γ-rays at 250, 760, 910 and 1680 keV were observed in UZ. The coincidence relations between γ-rays, and also between the γ-rays and the β-radiation, have been investigated. A decay scheme is proposed and spin and parity assignments have been made for some of the levels of Pa^{234} and U^{234}. A.

539.163.2

1148. Disintegration of Ce^{139}. C. H. PRUETT AND R. G. WILKINSON. *Phys. Rev.*, **96**, *No.* 5, 1340–3 (*Dec.* 1, 1954).

The decay of Ce^{139} is shown to proceed by *s*-electron capture to a single excited state of La^{139} with the subsequent emission of an internally converted γ-ray. Magnetic β-ray spectrometry and scintillation coincidence techniques have been used to show that the 166 keV γ-ray is magnetic dipole in character. The measured $K/(L+M)$ ratio is $6{\cdot}6 \pm 0{\cdot}3$. An estimation of the K internal conversion coefficient yields $0{\cdot}20 \pm 0{\cdot}05$ and the lifetime of the excited level is found to be less than 10^{-8} sec. An upper limit of 315 keV is found for the total disintegration energy. Although no estimate of orbital electron capture to the ground state can be made, a small amount is probable. A value of $0{\cdot}94 \pm 0{\cdot}02$ for the K fluorescent yield at $Z = 57$ is obtained from the experiment. A.

539.163.2

1149. Radiations from Ho^{164}. H. N. BROWN AND R. A. BECKER. *Phys. Rev.*, **96**, *No.* 5, 1372–8 (*Dec.* 1, 1954).

The decay modes of 36·7 min Ho^{164} have been studied with a magnetic spectrometer, scintillation spectrometer and proportional counter. Decay to the two even-even daughters, Dy^{164} by orbital electron capture, and Er^{164} by β-decay, is indicated. The β-spectrum appears to be complex, with maximum energy $0{\cdot}99 \pm 0{\cdot}03$ MeV. γ-rays of energy 90·5, 72·8 and 37·3 keV, together with X-rays at 45·7 keV, are found. There is also evidence for a γ-ray at approximately 46 keV. Photon-photon coincidences are found for 46–73 and 37–46 keV approximate energies. Photon-β coincidences are found to involve photons of approximate energy 91 and 50 keV. The data are interpreted in terms of first excited levels at 72·8 keV in Dy^{164}, 90·5 keV in Er^{164}, with probably a second level in Dy^{164} at 110 keV. Delayed photon-β and photon-photon coincidences were found with a half-life of $1{\cdot}4 \times 10^{-9}$ sec. The former are associated with the 90·5 keV level of Er^{164}; the assignment of the photon-photon coincidences is uncertain. A possible isomeric transition in Ho^{164} is also suggested. Spin and parity assignments, on the basis of conversion coefficients and $\log(f_0 t)$ values, are made for certain of the levels. A.

539.164.2

1150. On the semi-empirical mass-formula and alpha-disintegration energy in the region of heavy and medium heavy nuclides. G. P. DUBE AND L. S. SINGH. *Proc. Indian Acad. A*, **40**, *No.* 1, 37–46 (*July*, 1954).

It is shown that Fermi's semi-empirical atomic mass-formula is inadequate for the estimation of α-disintegration energy in the medium heavy and heavy nuclide-regions. A suitable correction-term has been added to the mass-formula based on Duckworth's new atomic masses and similar to the one proposed by Stern for heavy elements ($A \geqslant 208$). It is seen that the calculated α-decay energies are in numerical agreement with the observed data except for the magic number nuclei which can be satisfactorily explained on the nuclear shell-structure. But even in the latter case the agreement with the experimental results is better when the correction-term is used. A.

539.164.2

1151. Alpha-decay theory and a surface well potential. G. H. WINSLOW. *Phys. Rev.*, **96**, *No.* 4, 1032–44 (*Nov.* 15, 1954).

A discussion is given of the escape of an α-particle from a square-well potential which is in the form of a spherical shell surrounding the daughter nucleus. In the present approximation the α-particle, as such, is excluded from the interior of the nucleus by making the one-body potential infinite in that region. The usual Coulomb barrier is used. It is found that the properties of this model differ in several important respects from those of the usual square-well one-body model, in which the well is located at the origin of coordinates. Arguments are presented which lead to the representation of the many-body decay constant as the product of a dimensionless "preformation factor" and a one-body decay constant, as opposed to the usual product of an intrinsic nonbarrier decay constant and a dimensionless barrier transmission coefficient. The preformation factor involves an "intrinsic" α-decay probability and, in addition, the probability per sec that an α-particle at the nucleus will be absorbed as nucleons. The nuclear physics problem of deriving expressions for these latter two probabilities is not considered, but examples are given which can be used to show expected ranges of numerical values of the preformation factor when the one-body model is either the present one or the usual one. A.

539.164.75

1152. Determination of the ranges and straggling of low-energy alpha particles in a cloud chamber. S. BARILE, R. WEBELER AND G. ALLEN. *Phys. Rev.*, **96**, *No.* 3, 673–9 (*Nov.* 1, 1954).

Ranges of 105 α-particles with energies of 0·48, 0·545 and 0·615 MeV as fixed by a velocity selector have been measured by the use of a low-pressure cloud chamber. From the results of these measurements the average ranges R_{Av} and the straggling coefficients in air at 15° and 760 mm were calculated for these three energies. The values of R_{Av} were found to be respectively 0·299, 0·327 and 0·354 cm; and the values of the standard deviation were respectively 0·011, 0·0135 and 0·010 cm. After a correction to take into account the difference in definition, the R_{Av}'s are two to three per cent higher than those following from a range-energy curve given by Bethe. A.

539.165

1153. Beta spectrum of C^{14}. H. H. FORSTER AND A. OSWALD. *Phys. Rev.*, **96**, *No.* 4, 1030–1 (*Nov.* 15, 1954).

The β-spectrum from thin sources of C^{14} was measured in a double thin-lens β-ray spectrometer; the momentum spectrum and the Fermi plot are presented. The Fermi plot for a source of approximately 15 $\mu g/cm^2$ is a straight line down to about 30 keV; the experiment therefore indicates an allowed shape for the β-spectrum of C^{14}. Existing experimental evidence to the contrary, that is, for a forbidden spectrum, is discussed and compared with the results of the present experiment. A.

539.165 : 550.93

1154. The potassium–argon method of geological age determination. H. A. SHILLIBEER AND R. D. RUSSELL. *Canad. J. Phys.*, **32**, *No.* 11, 681–93 (*Nov.*, 1954).

The development of the potassium–argon method for dating minerals is discussed. The decay scheme for radioactive potassium-40 is examined. The results of 11 recent counting experiments have been averaged and give a mean value of $29{\cdot}4 \pm 2{\cdot}7$ β-emissions per second per gram of potassium. Averaging the 15 previous determinations of the rate of γ-decay gives a branching ratio of $0{\cdot}090 \pm 0{\cdot}038$ with the above β-decay rate. This is in close agreement with a branching ratio of 0·089 suggested by the authors in a previous paper on the basis of two potassium–argon determinations. Methods of measuring the radiogenic argon content of potassium minerals are discussed and the method in use at this laboratory is described in detail. Yield runs and grain size experiments have been carried out and are reported. Potassium–argon ages have been calculated for four perthites and two lepidolites. These ages are in excellent agreement with the best available ages obtained by other methods. A.

539.165.08

1155. On the determination of the relative intensities of conversion lines recorded photographically in a semi-circular beta-ray spectrograph. H. SLÄTIS. *Ark. Fys.*, **8**, *Paper* 43, 441–50 (1954).

In order to compare the relative intensities of photographically recorded conversion lines the density-exposure relation, the density-energy relation and the density-radius relation were studied. It is shown that reliable results are obtained when instead of the integrated areas of the conversion lines (photometrically recorded and changed to electron density curves) the product is taken of the true half-width and the electron density difference between the top and the background of the line. The method developed is tested on conversion lines in the β-spectra of ThB and RaB. A.

539.165.08

1156. The effect of back-scattering of electrons on measurements in β-spectroscopy and absolute counting. J. G. BALFOUR. *J. sci. Instrum.*, **31**, *No.* 11, 395–8 (*Nov.*, 1954).

The results of different observers on the back-scattering of electrons and β-particles from various scattering materials show some measure of disagreement. Consequently, fresh measurements were made by means of a proportional counter using Te^{125m} as a source of three roughly monoenergetic groups of electrons within the energy range 0–105 keV. Relationships were found between the coefficient of back-scattering, the energy of the primary electrons and the atomic number of the backing material. The results are in fairly good agreement with those obtained previously with a source of β-particles placed outside the thin end-window of a Geiger counter, but show marked disagreement with those obtained with the source placed inside the Geiger counter. The new measurements are related to the techniques of β-spectroscopy and absolute counting, particularly where this involves proportional counters and 2π geometry. A.

539.165.2

1157. Note on the relation between certain forbidden beta transitions and the nuclear spin orbit interaction. G. N. FOWLER. *Proc. Phys. Soc.* [*London*] *A*, **67**, *Pt* 11, 1005–9 (*Nov.*, 1954).

The second-forbidden β-decay matrix element A_{ij} is given in terms of the nuclear spin orbit potential strength u and another second-forbidden β-decay matrix element R_{ij}. The result is used, together with the predictions of the Mayer shell model for the single particle configurations, to obtain an estimate of u from the decay of Tc^{99} for two types of space dependence of the spin orbit potential. The result is in reasonable agreement with that found from a study of the stationary states of He^5. A.

539.166

1158. Polarized γ-rays from oriented ^{54}Mn nuclei. G. R. BISHOP, J. M. DANIELS, H. DURAND, C. E. JOHNSON AND J. PEREZ. *Phil. Mag.*, **45**, 1197–9 (*Nov.*, 1954).

The plane polarization of the γ-ray emitted in the decay of Mn^{54} to Cr^{54} has been measured using nuclei oriented by magnetic hyperfine structure at very low temperatures. It is found that the excited state of Cr^{54} decays by an $E2$ transition, and it is furthermore concluded that this state has even parity. [See also Abstr. 1117 (1955)]. A.

539.166

1159. Electric excitation of Au^{197}. C. F. COOK, C. M. CLASS AND J. T. EISINGER. *Phys. Rev.*, **96**, *No.* 3, 658–63 (*Nov.* 1, 1954).

The γ-radiation emitted from Au^{197} following the electric excitation of the nucleus by protons of from 2 to 5 MeV has been studied. The angular distributions and absolute yields of the two intense γ-rays of the spectrum at 279 and 555 keV have been measured. The angular distributions of these two γ-rays were found to agree well with those calculated for $5/2 \rightarrow 3/2$ $(M1 + E2)$ and $7/2 \rightarrow 3/2$ $(E2)$ transitions respectively, the excitation being $E2$ in both cases. The yield from the 279 keV state was observed to increase with beam energy in the manner predicted by theory for electric quadrupole excitation. On the basis of the Bohr–Mottelson unified model of the nucleus the results indicate a larger than expected cross-section for the formation of the 555 keV state. Values for the quadrupole moment and magnetic moment of the ground state of gold calculated from the cross-section for the formation of the 279 keV state agree with spectroscopic values. A.

539.166

1160. Emission of high-energy gamma line from C^{12}. D. COHEN, B. J. MOYER, H. SHAW AND C. WADDELL. *Phys. Rev.*, **96**, *No.* 3, 714–15 (*Nov.* 1, 1954).

A γ-ray of energy 15·2 MeV has been observed with a 180° pair spectrometer in the bombardment of carbon by protons of energy 30–340 MeV. The line is also seen in deuteron bombardment of B^{11}, but not of B^{10}. These facts, along with energetics arguments and clear spectrometer separation from known lines in excited Be^8, strongly indicate an excited C^{12} origin for the line. It is tentatively proposed that the excited C^{12} level here involved is a $T = 1$ state for which isotopic spin selection rules forbid a disintegration into three α-particles. A.

539.166

1161. Gamma-ray energies in the decay of Cs^{134}. M. C. Joshi and B. V. Thosar. *Phys. Rev.*, **96**, *No.* 4, 1022–3 (*Nov.* 15, 1954).

The photoelectric conversion spectrum of γ-rays in the decay of Cs^{134} was studied with a newly installed Siegbahn–Slätis β-ray spectrometer, using a strong source and thick lead and uranium radiators to bring out weak lines. Lines corresponding to the following γ-rays were found (expressed in keV) 467; 553; 571; 607; 794; 1027; 1164; 1368; 1401. A.

539.166

1162. Angular distribution of 12- and 16-MeV gamma rays from the proton bombardment of a thin boron target. H. H. Givin, G. K. Farney, T. M. Hahn and B. D. Kern. *Phys. Rev.*, **96**, *No.* 5, 1337–9 (*Dec.* 1, 1954).

The angular distribution of 12 and 16 MeV γ-rays has been obtained for proton energies ranging from 0·6 to 2·0 MeV. The angular distribution may be represented by the equation $w(\theta) = 1 + A\cos\theta + B\cos^2\theta$, indicating interference between at least two levels of opposite parity. An analysis of the energy dependence of the coefficients A and B for the 16 MeV γ-rays indicates the interference to be between more than two levels. A.

539.166 : 539.165

1163. Energies of the radiations from Ce^{144} and Pr^{144}. J. M. Cork, M. K. Brice and L. C. Schmid. *Phys. Rev.*, **96**, *No.* 5, 1295–7 (*Dec.* 1, 1954).

With scintillation and magnetic photographic spectrometers the energies of the γ-rays from Ce^{144} have been re-evaluated. Several previously reported γ-rays are believed not to exist, while certain others not reported are found to occur. γ-energies of 33·4, 40·8, 53·2, 59·0, 79·9, 95·0, 133·5 and 145·2 keV are found. Coincidence measurements together with a consideration of energy relationships indicate a reasonable level scheme for the Pr^{144} nucleus. The energies of the three high-energy γ-rays in Nd^{144} following β-decay of Pr^{144} are 0·688, 1·49 and 2·18 MeV. Some relative intensity measurements are made of the conversion electron lines, leading to a prediction of the multipolarities for three of the γ-transitions. The β-spectrum from Ce^{144} resolves into components with upper energies of 327, 258 and 160 keV. The β-radiation from Pr^{144} has an upper energy limit at 3·12 MeV with a lower energy component whose maximum energy is 0·92 MeV. A.

539.166.74

1164. Resonance scattering of gamma rays by nuclei. A. M. Cormack. *Phys. Rev.*, **96**, *No.* 3, 716–18 (*Nov.* 1, 1954).

Two methods of observing the nuclear resonance scattering of γ-rays are discussed: one using γ-rays which arise from transitions to the ground state of a nucleus which is the same as the one in which the scattering is being observed, and the other using γ-rays of small energy spread and variable mean energy obtained by means of Compton scattering. A.

539.166.83

1165. Electron energy distributions produced by gamma-rays. H. E. Johns, J. E. Till and D. V. Cormack. *Nucleonics*, **12**, *No.* 10, 40–6 (*Oct.*, 1954).

Tables setting out the yield of secondary electrons produced per unit energy interval, by monokinetic and continuous spectrum γ-radiation absorbed in water, are given. An expression relating electron flux density to the number of secondary electrons produced per unit volume is derived. The application of these data to the calculation of local energy absorption, ionization in a small gas-filled cavity and the determination of ion density distributions, is described. L. R. SHEPHERD

539.166.835

1166. Note on the Z-dependence of the cross-section for pair production. A. Z. Hrynkiewicz. *Acta phys. Polon.*, **13**, *No.* 3, 205–8 (1954).

A new interpretation of experimental results of previous works of the author on this subject is given. The Z-dependence of the cross-section for pair production by γ-rays of ThD (2·62 MeV) was found to be consistent with the theory of Jaeger and Hulme. A.

539.166.835

1167. Three-quantum annihilation of positrons in solids. R. L. Graham and A. T. Stewart. Letter in *Canad. J. Phys.*, **32**, *No.* 10, 678–9 (*Oct.*, 1954).

The three-quantum decay rate of positrons entering various solids was measured by a triple coincidence method. Metals and crystalline solids gave similar low rates: higher rates were given by certain non-crystalline solids, which had been previously shown to give a complex positron decay scheme, giving a longer lifetime in addition to the shorter lifetime in metals [Abstr. 5049 (1953)]. The variation of the three-quantum rate for teflon with temperature showed a correlation with the variation of the longer lifetime. This evidence tends to support the postulate that the long lifetimes are due to formation of triplet positronium atoms. J. HAWGOOD

539.166.835

1168. Direct quantitative observation of the three-photon annihilation of a positron-negatron pair. J. K. Basson. *Phys. Rev.*, **96**, *No.* 3, 691–6 (*Nov.* 1, 1954).

Three-photon annihilation of the positron with a negatron has been determined quantitatively as well as qualitatively by the simultaneous observation of the emitted photons with scintillation counters. The ratio of the reaction cross-sections for two- and three-photon annihilation has been determined as $\sigma_{2k}/\sigma_{3k} = 402 \pm 50$. This is in agreement with the theory of Ore and Powell but definitely differs from the theoretical values obtained by Lifshitz and by Ivanenko and Sokolov. A.

539.166.835

1169. Effect of nuclear charge on internally produced pairs. G. K. Horton and E. Phibbs. *Phys. Rev.*, **96**, *No.* 4, 1066–75 (*Nov.* 15, 1954).

The effect of nuclear charge on internally converted pairs is investigated using the relativistic Sommerfeld–Maue solutions of the iterated Dirac equation. The orthonormal properties of these wave-functions are studied and time-dependent perturbation theory is adapted to allow for their nonorthogonality. The integrals involved are studied using the Fourier transforms of the wave-functions. The matrix elements are obtained in terms of one fundamental integral, evaluated by using an integral representation of Butler. The procedure is very simple and promises generalizations. The matrix elements are shown to be complex

only through $n = \mp iZ/(137v_{\pm})$, where $v_{\pm}$ is the velocity of the positron or the negatron and Z is the nuclear charge. The following conclusions are drawn. Firstly, the first Born approximation results when multiplied by the well-known Sommerfeld factors of the negatron and positron are accurate to a term proportional to $|n|^2$. For 5% resolutions, $Z \lesssim 20$, the kinetic energy must be more than 100 keV. Secondly, this result is valid for all electric and magnetic multipole transitions. Finally, this result is shown to apply to all transitions taking place between unbound states and to hold for higher-order perturbation terms. A.

539.166.84

1170. Differential cross-section measurements for 1 MeV bremsstrahlung. J. W. MOTZ AND W. MILLER. Letter in *Phys. Rev.*, **96**, *No.* 2, 544–5 (*Oct.* 15, 1954).

The energy and angular distribution of the bremsstrahlung produced in thin targets of beryllium and gold by 1 MeV electrons was measured using a large NaI(Tl) scintillation spectrometer. The pulse-height distribution was measured with a 12-channel analyser. The response of the spectrometer as a function of plot on energy was found from the response curves measured for photons from Co^{60}, Cs^{137}, Hg^{203} and Cd^{109}. Measurement of the bremsstrahlung spectra were made at angles of 10°, 30° and 90° and the differential cross-section at different angles plotted as a function of photon energy, and compared with the theoretical curves based on the Born approximation due to Sauter. The prediction of large intensity variation with angle was confirmed, but although the measured integrated intensity varies as Z^2, the measured spectral shape is Z-dependent. The theoretical curves appear to underestimate the measured cross-sections. D. R. CHICK

539.166.84

1171. Thick target bremsstrahlung spectra for 1·00-, 1·25-, and 1·40-MeV electrons. W. MILLER, J. W. MOTZ AND C. CIALELLA. *Phys. Rev.*, **96**, *No.* 5, 1344–50 (*Dec.* 1, 1954).

The spectrum of radiation produced by 1·0, 1·25, and 1·40 MeV electrons incident on a thick tungsten target was measured at 0° and 90° with the incident beam by a method involving the magnetic analysis of Compton electrons. The effects of electron scattering and energy loss in the target preclude any simple interpretation of this data to yield a differential bremsstrahlung cross-section. However, an estimate of the spectra to be expected at 0° and 90° was obtained by combining the Sauter expression for the bremsstrahlung cross-section with the available information on electron scatter and energy loss in the target and backscatter from the target. The reliability of the estimate is limited because the Sauter formula was calculated by using the Born approximation, the electron scattering calculations are applicable to an infinite medium only, and the backscatter was estimated empirically from Bothe's experimental data which were obtained with lower energy electrons (370 keV). Furthermore electron energy straggling was neglected. Nevertheless, the predicted spectral shapes at 0° and 90° and the relative intensities at these two angles are in qualitative agreement with the measured values. The absolute magnitudes of the measured intensities at both angles are about a factor of two greater than the predicted values. A.

539.167.3

1172. Isotope production: how to choose irradiation time. W. B. LEWIS. *Nucleonics*, **12**, *No.* 10, 30–3 (*Oct.*, 1954).

Expressions are derived for the yields of various products in a radioactive chain, where production and destruction are determined by radioactive decay and neutron absorption. The results are applied (*a*) to the case of the production of Au^{198} and Au^{199} when Au^{197} is irradiated in neutron fluxes of 10^{14} and 5×10^{11} n/cm²/sec., and (*b*) to the irradiation of thulium to form Tm^{170}. L. R. SHEPHERD

539.169

1173. Advances in isotope techniques. R. A. FAIRES, J. E. JOHNSTON AND R. J. MILLETT. *Nucleonics*, **12**, *No.* 10, 48–51 (*Oct.*, 1954).

Short summaries of the papers presented at the Second Radioisotope Conference held at Oxford, dealing with the application of radioisotopes in industry, physics, chemistry, metallurgy, biology, biochemistry, and medicine. The physics applications discussed include the measurement of deuterium by observation of photoneutrons emitted under Na^{24} γ-irradiation and the incorporation of the C^{14} activity into an acetylene counter gas in the radiocarbon-dating of archaeological specimens. L. R. SHEPHERD

NUCLEAR REACTIONS 539.17

539.17 : 518.3

1174. Nomogram for nuclear reaction calculations. F. J. M. FARLEY. *Nucleonics*, **12**, *No.* 10, 56–7 (*Oct.*, 1954).

The nomogram enables particle energy direction and intensity in the laboratory frame of reference to be related to the corresponding quantities in the centre-of-mass frame.

539.172

1175. Energy distribution of nuclear reaction products. H. H. BARSCHALL AND J. L. POWELL. *Phys. Rev.*, **96**, *No.* 3, 713 (*Nov.* 1, 1954).

In a reaction involving two product particles the distribution in energy of either product particle measured in the laboratory system is the same as the distribution in angle in the zero-momentum system. This relation is valid relativistically and irrespective of the reaction energy. Some applications are discussed. A.

539.172

Nuclear reactions due to cosmic rays. *See also under* "Cosmic rays." Decimal classification 537.591.8

539.172

1176. Nuclear multipole transitions in inelastic electron scattering. L. I. SCHIFF. *Phys. Rev.*, **96**, *No.* 3, 765–72 (*Nov.* 1, 1954).

Expressions are obtained for the differential cross-sections for inelastic scattering of fast electrons with

excitation of various nuclear multipole transitions. The most probable transitions are those that involve collective motion of many nucleons, and in this case the term arising from the transition charge density dominates those that come from the current and magnetization densities. There is then a close relation between the probability for inelastic electron scattering and the probability for the corresponding radiative electric multipole transition, although an assumption must be made as to the shape of the transition charge density. This is illustrated with a detailed discussion of the collective electric quadrupole transitions, using the model of Bohr and Mottelson. When the transition is produced by one or a small number of nucleons, or when it is of magnetic multipole type, there is likely to be little relation between inelastic scattering and radiation probabilities. The electric monopole transition ($0+ \rightarrow 0+$) is also discussed. It is shown how the elastic scattering can be corrected for unresolved inelastic scattering as well as elastic quadrupole scattering before an analysis is made in terms of the spherically symmetric part of the static nuclear charge density, and also how the strength as well as the shape of the transition charge density can be determined experimentally when only relative measurements of inelastic scattering are available. A.

539.172.11

1177. Coulomb excitation of F^{19} by alpha particles. R. Sherr, C. W. Li and R. F. Christy. *Phys. Rev.*, **96**, *No.* 5, 1258–66 (*Dec.* 1, 1954).

Gamma-rays emitted in the excitation of F^{19} by α-particles of 0·6 to 2·8 MeV have been studied. Resonances are found in the reaction $F^{19}(\alpha, p)Ne^{22*}$ at α-particle energies greater than 1·3 MeV and in the inelastic excitation of 109 keV and 196 keV levels in F^{19} at energies greater than 2·2 MeV. At bombarding energies below 2 MeV, the cross-sections for inelastic excitation of F^{19} decrease much too slowly for compound nucleus formation and are identified as being due to Coulomb excitation. The observed cross-sections in the region 0·6 MeV to 2 MeV agree well with the theory for Coulomb excitation. The electromagnetic transition probabilities for decay of these states deduced from the excitation cross-sections are in good agreement wtih those found from direct measurement of the lifetimes by Thirion, Barnes, and Lauritsen. Together with the results of Peterson, Barnes, Fowler, and Lauritsen on the inelastic excitation of fluorine by protons, these experiments lead to spin and parity assignment of $\frac{1}{2}^-$ for the 109 keV state and $\frac{5}{2}^+$ for the 196 keV state of F^{19}. The observed angular distributions of the γ-rays from Coulomb excitation by α-particles are also in accord with theory. A.

539.172.13

1178. Interaction of protons with H^3 and excited states of the alpha particle. A. I. Baz' and Ya. A. Smorodinskiĭ. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9), 382–4 (1954) In Russian.

Experimental evidence, especially the reaction $H^3(p, n)He^3$, can be interpreted as indicating the system $H^3 + p$ to have two broad levels: $J = 2^-$, $T = 0$ at 22 MeV; $J = 1^-$, $T = 0$ about 1–2 MeV higher. G. E. Brown

539.172.13

1179. Radiations from the proton bombardment of ^{23}Na. F. C. Flack, J. G. Rutherglen and P. J. Grant. *Proc. Phys. Soc.* [*London*] *A*, **67**, *Pt* 11, 973–80 (*Nov.*, 1954).

The excitation functions and absolute yields of the reactions $Na^{23}(p, \gamma)\ Mg^{24}$ and $Na^{23}(p, \alpha)\ Ne^{20}$ have been measured for proton energies between 250 and 700 keV. Resonances for the emission of γ-radiation were found at 310, 515, 593 and 679 keV, and for α-particle emission at 287, 338 and 593 keV. The spectrum of γ-radiation was measured at each resonance together with the relative intensities of the γ-rays. A decay scheme is given which has been verified by γ–γ coincidence measurements. A.

539.172.13

1180. γ rays from the $C^{13}(p,\gamma)N^{14}$ and $Na^{23}(p,\gamma)Mg^{24}$ reactions. B. Hird, C. Whitehead, J. Butler and C. H. Collie. *Phys. Rev.*, **96**, *No.* 3, 702–3 (*Nov.* 1, 1954).

The γ-rays from the 554 keV resonance of $C^{13}(p, \gamma)N^{14}$ and the 310 keV resonance of $Na^{23}(p, \gamma)Mg^{24}$ have been measured with a three-crystal pair spectrometer. Energies and intensities were measured and cascades detected by coincidence measurements. The 5·7 MeV γ-ray from $C^{13}(p, \gamma)N^{14}$ is $0{\cdot}7 \pm 0{\cdot}6\%$ of the intensity of the main 8·05 MeV radiation. The most intense radiation from $Na^{23}(p, \gamma)Mg^{24}$ was the 1·38 MeV line, and no 2·76 MeV radiation was observed. A.

539.172.13

1181. Scattering of 10 MeV protons on carbon and magnesium. G. E. Fischer. *Phys. Rev.*, **96**, *No.* 3, 704–8 (*Nov.* 1, 1954).

In order to study the mechanism of excitation of nuclear levels by inelastic scattering, a scattering chamber of 36 in. dia. was constructed. The deflected beam of the Berkeley 60 in. cyclotron was brought out of the shielding by means of strong focusing magnets. Particles from the nuclear reactions were detected by either of two systems, a quadruple proportional-counter telescope, or a coincidence crystal spectrometer. Energy resolution was of the order of 2·5%. The angular distribution of protons from the reactions $C^{12}(p,p')C^{12*}$, $Q = -4{\cdot}43$ MeV, and $Mg^{24}(p, p')Mg^{24*}$, $Q = -1{\cdot}38$ MeV, were found to be peaked in the forward direction. Since the compound nucleus is excited to about 13 MeV, where the level density is expected to be high and the statistical theory of the nucleus should hold, it is proposed that two processes of excitation occur. One, the formation of the compound nucleus and its subsequent decay—symmetrically about 90°; two, direct collision of the incident proton with a nucleon on the surface shell of the nucleus. The elastic scattering of protons on the above nuclei was also studied and interference maxima were found. Three new levels are believed to have been confirmed in magnesium. A.

539.172.13

1182. Resonances in $Li^7(p, n)Be^7$. R. K. Adair. *Phys. Rev.*, **96**, *No.* 3, 709–12 (*Nov.* 1, 1954).

An investigation of experimental data concerning the $Li(p,n)$ reaction indicates that the resonance at 2·25 MeV proton energy is due to the influence of a spin 3, isotopic spin 1, even parity level of Be^8,

19·2 MeV above the ground state, and that the background reaction intensity is predominantly the result of a spin-1 state of odd parity, and a spin-2 state of odd parity and isotopic spin 0. Cross-sections, angular distributions, and neutron polarizations calculated on this basis are in good agreement with previous experimental measurements of these quantities. The neutron and proton widths of the isotopic spin-one state in Be^8 are related to the neutron width of the corresponding isotopic spin-one state of Li^8, 2·3 MeV above the ground state, in a manner consistent with the transition probability relationships expected of a nuclear isotopic spin multiplet. A.

539.172.13

1183. Fission and total reaction cross sections for 22 MeV protons on Th^{232}, U^{235}, and U^{238}. G. H. McCormick and B. L. Cohen. *Phys. Rev.*, **96**, *No.* 3, 722–4 (*Nov.* 1, 1954).

Absolute excitation functions for (p,f) reactions in Th^{232}, U^{235} and U^{238}, were measured by radiochemical techniques; at 21·5 MeV, the cross-sections are 0·83, 1·31 and 1·28 barn, respectively (± 15% in each case). Cross-sections for (p,xn) reactions in U^{238} were found to be quite small. The total reaction cross-sections correspond to a nuclear radius of $(1·55 \pm 0·1)A^{\frac{1}{3}} \times 10^{-13}$ cm. Some advantages of determining the nuclear radius by total reaction cross-sections are pointed out, and the discrepancy between electromagnetic and nuclear determinations of the nuclear radius is discussed. A.

539.172.13

1184. Energy levels of Al^{27}. C. P. Browne, S. F. Zimmerman and W. W. Buechner. *Phys. Rev.*, **96**, *No.* 3, 725–9 (*Nov.* 1, 1954).

Proton groups inelastically scattered from Al^{27} were observed with a high-resolution magnetic analyser. Bombarding energies between 5·6 and 8·4 MeV were provided by an electrostatic generator. Twenty-two levels have been observed up to 6 MeV excitation. Discrepancies with previous work, both as to number and position of levels, appear. A level at 1·777 MeV in Si^{28} was also measured. A.

539.172.13

1185. Polarization of protons by scattering from beryllium. H. G. de Carvalho, J. Marshall and L. Marshall. *Phys. Rev.*, **96**, *No.* 4, 1081–5 (*Nov.* 15, 1954).

The polarization of high-energy protons scattered from beryllium has been investigated as a function of energy and angle of the scattered protons. It was found that the elastically scattered protons are much more strongly polarized than the quasi-free nucleon-scattered protons. A.

539.172.13

1186. Reactions of cobalt with protons at 60, 100, 170, and 240 MeV. G. D. Wagner and E. O. Wiig. *Phys. Rev.*, **96**, *No.* 4, 1100–3 (*Nov.* 15, 1954).

Absolute cross-sections are reported for the production of the nuclides Co^{58}, Co^{56}, Co^{55}, Fe^{52}, Mn^{56}, Mn^{52}, Mn^{51}, Cl^{39} and $Cl^{38,34}$ from bombardment of Co^{59} with protons of energies 60, 100, 170 and 240 MeV. The yields appear to be accounted for at the lower energies by a combination of compound nucleus model, knock-on cascade model and for the production of chlorine isotopes a fission mechanism. A knock-on cascade model together with a fission mechanism may be used to explain the yields at the higher energies. A.

539.172.13

1187. Fluorine-plus-proton reactions. R. W. Peterson, W. A. Fowler and C. C. Lauritsen. *Phys. Rev.*, **96**, *No.* 5, 1250–8 (*Dec.* 1, 1954).

The properties of certain energy levels in O^{16}, F^{19} and Ne^{20} have been studied by observations on the α-particles and inelastic protons from the bombardment of fluorine by protons. A high-resolution magnetic analysis of the α-particle groups to the 2^+ and 1^- levels in O^{16} from the $F^{19}(p,\alpha)O^{16*}$ reaction failed to reveal any doublet structure in these known levels. The angular distributions of the α-particle groups to these levels did not indicate degeneracy with a 2^- level, nor did a search for new excited levels in O^{16} up to 8·7 MeV excitation reveal a 2^- level. These results are not in agreement with the α-particle model of the O^{16} nucleus which predicts a 2^- state close in energy to the 2^+ state. Angular distributions of the α-particles were measured at proton bombarding energies of 873, 935, 1290, 1355 and 1381 keV. The distributions at 1355 keV indicated that the corresponding Ne^{20} resonance level at 14·16 MeV has spin 2 and odd parity. The spin and parity assignments previously found for the other levels were confirmed. A study of the inelastic proton groups from the $F^{19}(p,p')F^{19*}$ reaction gave 108·8 ± 0·8 and 196·0 ± 1·4 keV for the excitation energies of the two lowest excited levels of F^{19}. The cross-sections at the 1431 keV resonance for these groups in the centre-of-mass system were 0·187 ± 0·015 barn for the first group and 0·007 ± 0·002 barn for the second group. At 1381 keV the cross-section was 0·0427 ± 0·0040 barn for protons to the second excited level. Angular distributions of the proton groups were measured and, in conjunction with other studies made in this laboratory, resulted in spin and parity assignments of $\frac{1}{2}^-$ and $\frac{3}{2}^+$ for the first and second excited states of F^{19}, respectively. A.

539.172.13

1188. Elastic scattering of 9·7-MeV protons by He^4. B. Cork and W. Hartsough. *Phys. Rev.*, **96**, *No.* 5, 1267–8 (*Dec.* 1, 1954).

The differential cross-section for the scattering of 9·7 MeV protons from helium has been measured over the range from 17° to 154° in the centre-of-mass system. The new 9·9 MeV proton linear accelerator, which is now used as an injector for the Bevatron, was used as a source of incident protons. A scattering chamber has been used that has the solid angles at the various scattering angles determined by fixed slits. The scattered particles were detected with sodium iodide scintillators and RCA 6199 photomultiplier tubes. The detectors were conveniently arranged so that they could be interchanged and three angles have been measured simultaneously, with a statistical accuracy in the forward direction of better than ± 1%. The differential cross-section measurements of the forward angles are in good agreement with published data in this energy region. However, the cross-section for protons scattered in the backward direction is approximately 75% of the published value. A.

539.172.13

1189. Scattering of 9·5-MeV protons by nitrogen. R. G. Freemantle, D. J. Prowse and J. Rotblat. *Phys. Rev.*, **96**, *No.* 5, 1268–9 (*Dec.* 1, 1954).

The elastic and inelastic scattering of 9·5 MeV protons by N^{14} nuclei has been studied by means of photographic emulsions. Groups of inelastically scattered protons have been observed due to the excited states of N^{14} at 2·3, 3·9, 4·9 and 5·1 MeV; the first of these was excited in a very low intensity. Angular distributions have been determined for the elastic group of protons as well as for the inelastic group corresponding to the 3·9 MeV state; the latter curve is symmetrical about 90°. A.

539.172.13

1190. Scattering of 9·5 MeV protons by neon and argon. R. G. Freemantle, D. J. Prowse, A. Hossain and J. Rotblat. *Phys. Rev.*, **96**, *No.* 5, 1270–1 (*Dec.* 1, 1954).

The photographic emulsion technique was employed to study the scattering of 9·5 MeV protons by neon and argon. Energy levels of Ne^{20} at 1·58, 4·20, 4·95 and 5·62 MeV have been observed as well as of A^{40} at 1·48 MeV. Angular distributions have been determined for the protons elastically scattered by Ne^{20} and A^{40}, as well as for the inelastic groups from the 1·58 MeV level of Ne^{20} and the 1·48 MeV leve of A^{40}. A.

539.172.13 : 539.18

Neutral pion and deuteron production in 400 MeV *n–p* collisions. *See Abstr.* 1241

539.172.13

1191. Theory of (*d*, *p*) and (*d*, *n*) reactions. I. General theory ignoring Coulomb effects. I. P. Grant. *Proc. Phys. Soc.* [*London*] *A*, **67**, *Pt* 11, 981–9 (*Nov.*, 1954).

The differential cross-section for the (*d*, *p*) process is evaluated using a Green's function technique. Elastic scattering of the proton by an average central potential well is taken into account. A later specialization to the case of a harmonic oscillator potential gives a result similar to that of Horowitz and Messiah but having a closed form. Compound nucleus formation is discussed and it is shown that the (*d*, *p*) cross-sections for different angular momentum transfers l_n and j_n are always additive. Polarization of the emitted particles is considered. A.

539.172.13

1192. Angular distribution of neutrons from the reaction $^{11}B(d, n)^{12}C$ at 0·85 MeV bombarding energy. A. Graue. *Phil. Mag.*, **45**, 1205–9 (*Nov.*, 1954).

Angular distributions and energy spectra have been measured using the photographic plate technique. Energy levels in C^{12} are found at 4·4, 7·7, 9·6 and 12·7 MeV. The stripping process is suggested to be responsible for a large part of the neutron yield. The orbital angular momentum of the captured proton has been determined as $l_p = 1$ and 2 for the 4·4 MeV and 9·6 MeV level, respectively. A.

539.172.13

1193. Proton angular distributions from deuteron bombardment of Bi^{209}, Pb^{207}, and Y^{89}. N. S. Wall. *Phys. Rev.*, **96**, *No.* 3, 670–3 (*Nov.* 1, 1954).

These have been measured and an attempt made to interpret the results on the basis of the Butler stripping theory. The neutron added to Y^{89} is consistent with an $l_n = 2$ prediction. The last neutron in Pb^{208} shows a similarity to an $l_n = 1$, non-Coulomb theory angular distribution, but the Bi^{210} case is not readily capable of being interpreted with this theory. The results of these experiments are analysed on the basis of the shell model and the systematics of the binding energy of the last neutron. A.

539.172.13

1194. The D–D reaction. W. M. Fairbairn. *Proc. Phys. Soc.* [*London*] *A*, **67**, *Pt* 11, 990–5 (*Nov.*, 1954).

The two reactions $H^2(d, p)H^3$ and $H^2(d, p)He^3$ are examined under the assumption that they proceed via a stripping process. Coulomb effects are ignored. The angular distribution of the protons from the $H^2(d, p)H^3$ reaction, and the variation with bombarding energy of the forward cross-section are used for the comparison between the theoretical predictions and the experimental data. The agreement which is found is sufficiently good to justify the assumption that the reactions proceed partly via a stripping process. Stripping becomes the predominant process for bombarding energies greater than 5 MeV (lab.). A.

539.172.13

1195. The cross-sections and angular distributions of the D–D reactions between 150 and 450 keV. G. Preston, P. F. D. Shaw and S. A. Young. *Proc. Roy. Soc. A*, **226**, 206–16 (*Nov.* 9, 1954).

A thin gas target was used and the He^3 and H^3 particles from the reactions were counted in two proportional counters which were rotated to make angles between 20 and 135° (in the centre-of-mass system) with the incident deuteron beam. In contradiction to data previously published for this energy range, the angular distributions of the reactions are different, the asymmetry of the neutron-producing reaction being the greater. The total cross-section of the neutron reaction is greater than that of the proton reaction; the ratio of the cross-sections increases with bombarding energy. A.

539.172.13

1196. Proton groups from the reaction $O^{18}(d, p)O^{19}$. C. Mileikowsky and K. Ahnlund. *Phys. Rev.*, **96**, *No.* 4, 996–8 (*Nov.* 15, 1954).

Separated targets of O^{18} on thick and thin backings have been used in a search for proton groups from the reaction $O^{18}(d,p)O^{19}$. Three proton groups due to this reaction were found. Their energies were measured with a double focusing magnetic spectrometer which in this case was calibrated with known particle group energies from $B^{10}(d, p)B^{11}$ and $N^{14}(d, p)N^{15}$. The Q values of $O^{18}(d, p)O^{19}$ are $Q_1 = 1730 \pm 8$ keV, $Q_2 = 1636 \pm 8$ keV, and $Q_3 = 262 \pm 6$ keV. A.

539.172.13

1197. Magnetic analysis of the $O^{17}(d,p)O^{18}$ reaction. K. Ahnlund. *Phys. Rev.*, **96**, *No.* 4, 999–1000 (*Nov.* 15, 1954).

Separated isotopic targets of O^{17} were used to study the reaction $O^{17}(d, p)O^{18}$. The energy spectrum of protons from this reaction has been analysed at 61·0° and 134·7° to the incident 0·855 MeV deuteron beam, using a double focusing magnetic spectrometer and photographic detection. The survey covers a range of

excitation in O^{18} from 0 to 4·8 MeV. Two proton groups were identified with the reaction $O^{17}(d,p)O^{18}$, giving $Q_0 = 5821 \pm 10$ keV and $Q_1 = 3835 \pm 8$ keV. A.

539.172.13

1198. Magnetic analysis of the $Co^{59}(d,p)Co^{60}$ reaction. G. M. Foglesong and D. G. Foxwell. *Phys. Rev.*, **96**, *No.* 4, 1001–2 (*Nov.* 15, 1954).

Proton groups from cobalt targets bombarded with 5 MeV deuterons from the MIT-ONR electrostatic generator have been analysed with a 180-degree focusing magnetic spectrograph. The ground-state Q value for the $Co^{59}(d,p)Co^{60}$ reaction was found to be $5·283 \pm 0·008$ MeV. The 60 keV metastable state and thirty-four additional excited states were observed and their Q values measured. A.

539.172.13

1199. Radiative capture of deuterons by He^3. J. M. Blair, N. M. Hintz and D. M. Van Patter. *Phys. Rev.*, **96**, *No.* 4, 1023–9 (*Nov.* 15, 1954).

The excitation function for $He^3(d,\gamma)$ capture radiation, measured from $E_d = 0·2$ to $2·85$ MeV, exhibits a broad resonance at $0·45 \pm 0·04$ MeV, with a total cross-section of $0·05 \pm 0·01$ mb. Above this energy, the presence of nonresonant capture is observed. At $E_d = 0·58$ MeV, the radiation is isotropic from 0° to 90° within $\pm 10\%$. The measured γ-ray energy of $16·6 \pm 0·2$ MeV at resonance corresponds to a Q value for the $He^3(d,\gamma)Li^5$ reaction of $16·36 \pm 0·2$ MeV. The experimental radiation width at resonance is calculated to be 11 ± 2 eV, which is compared to the Weisskopf estimate for $E1$ transitions. A.

539.172.13

1200. Excitation curve for $C^{14}(d,p)C^{15}$ and properties of C^{15}. J. A. Rickard, E. L. Hudspeth and W. W. Clendenin. *Phys. Rev.*, **96**, *No.* 5, 1272–5 (*Dec.* 1, 1954).

The excitation function for $C^{14}(d,p)C^{15}$ has been studied with deuterons of energy 0·6 to 3·0 MeV. A previously suspected resonance was definitely established at a bombarding energy of 2·15 MeV, with a width of nearly 400 keV. Analysis of the excitation curve shows that its shape may be explained on the basis of a spin of 5/2(+) for the C^{15} ground state and a Q value of $0·15 \pm 0·15$ MeV. This leads to a mass of C^{15} of $15·0141 \pm 0·00015$ a.m.u. A.

539.172.13

1201. (d,p) reactions from carbon, nitrogen, and oxygen. A. Sperduto, W. W. Buechner, C. K. Bockelman and C. P. Browne. *Phys. Rev.*, **96**, *No.* 5, 1316–22 (*Dec.* 1, 1954).

Proton groups from the deuteron bombardment of thin targets of Formvar, polyethylene, and nylon have been analysed by magnetic deflection in a 180-degree spectrograph and at 90 degrees to the incident beam. The MIT–ONR electrostatic generator was used to provide a deuteron beam at several energies ranging from 5 to 8·5 MeV. A total of twenty-eight individual proton groups has been observed. On the basis of both the relative intensities from the different targets and the differential energy shift, all the groups were identified with levels in C^{13}, C^{14}, N^{15}, or O^{17}. The investigation covers the region of excitation up to energies corresponding approximately to the neutron binding energy in each of these nuclei. The results confirm previous knowledge of four proton groups from the $C^{12}(d,p)C^{13}$ reaction; two groups from $C^{13}(d,p)C^{14}$; seven groups from $N^{14}(d,p)N^{15}$; and four groups from $O^{16}(d,p)O^{17}$. In addition, eleven new particle groups were observed, two arising from the $C^{13}(d,p)C^{14}$ reaction and corresponding to energy levels in C^{14} at 6·723 and 6·894 MeV, and the remaining nine groups from the $N^{14}(d,p)N^{15}$ reaction and corresponding to levels in N^{15} at 7·575, 8·571, 9·062, 9·834, 10·069, 10·458, 10·544, 10·705, and 10·811 MeV. A.

539.172.13

1202. Angular distribution of protons from (d,p) reactions on Be^9, N^{14}, and Zn^{68}. F. S. Eby. *Phys. Rev.*, **96**, *No.* 5, 1355–62 (*Dec.* 1, 1954).

The (d,p) stripping theory of Butler has been employed in the interpretation of the angular distributions of protons resulting from the bombardment of foil targets of Be^9, N^{14}, and Zn^{68} by 11·9 MeV deuterons. A NaI(Tl) scintillation counter was used to detect protons emitted between angles of 5° and 90°, and pulses were recorded on a 35 mm film strip for pulse-height analysis. The distribution of protons from the reaction $N^{14}(d,p)N^{15}$ leaving N^{15} in its doublet first excited state was found to have a peak in the forward direction, indicating that the conclusion previously reached, i.e. that high momentum transfers are involved in this reaction, is probably incorrect. Although it was not possible to do so in the present work, it appears that stripping theory might be used to account for the proton distribution from this reaction if deuterons of higher energy were used. The orbital momenta of a pair of isomeric levels in the nucleus Zn^{69} as determined from the proton distributions and stripping theory are in agreement with the shell model assignments of $p_{1/2}$ for the ground state and $g_{9/2}$ for the 436 keV level. Higher excited levels of Zn^{69} are indicated at about 770 keV and 1·6 MeV. The distribution of the proton group leaving the final nucleus with an excitation of 770 keV is characterized by a momentum transfer, $l_n = 2$. The Q value for the reaction leaving Zn^{69} in the ground state was determined to be $4·16 \pm 0·15$ MeV. A.

539.172.13 : 539.152.1

1203. Neutron binding energies from (d,p) Q values. N. S. Wall. *Phys. Rev.*, **96**, *No.* 3, 664–9 (*Nov.* 1, 1954).

The Q values for the (d,p) reactions on some 27 targets whose neutron numbers are around the closed shells of 50 and 82 neutrons were determined. The general interpretation of these results and the specific application of these results to a variety of problems is discussed. In general, the results show a break of approximately 2 MeV at each of the shell edges. The technique used was that of a NaI scintillation spectrometer and is described in some detail. Comparison is also made with previous measurements by different techniques. A.

539.172.13

1204. Disintegration of Li^6 and Li^7 by 0·24-MeV tritons. K. W. Allen, E. Almqvist, J. T. Dewan and T. P. Pepper. *Phys. Rev.*, **96**, *No.* 3, 684–9 (*Nov.* 1, 1954).

The energy distributions of charged particles emitted in the bombardment of Li^6 and Li^7 by 0·24

MeV tritons have been obtained by magnetic analysis and by measuring pulse heights in a proportional counter. Q values for the reactions $Li^6(t,d)Li^7$, $Li^6(t,p)Li^8$, and $Li^7(t,\alpha)He^6$ were found to be $0{\cdot}986 \pm 0{\cdot}007$ MeV, $0{\cdot}790 \pm 0{\cdot}011$ MeV and $9{\cdot}79 \pm 0{\cdot}03$ MeV, respectively. The latter, when combined with other accurately measured Q values, leads to a He^6–Li^6 mass difference of $3{\cdot}55 \pm 0{\cdot}03$ MeV, which is in agreement with the most recent β-ray measurements. Evidence is also presented for an excited state of He^6 at $1{\cdot}71 \pm 0{\cdot}01$ MeV above the ground state. A.

539.172.13

1205. Charged particles from the bombardment of Li^7 by He^3. C. D. Moak, W. M. Good and W. E. Kunz. *Phys. Rev.*, **96**, *No.* 5, 1363–5 (*Dec.* 1, 1954).

A $(Li^7)_2SO_4$ target was bombarded with He^{3++} ions at 720 keV, and the energies of the charged particles emitted were analysed by means of a NaI spectrometer. The spectrum was found to consist in part of particles smoothly distributed in energy; and in part of relatively sharp groups of particles of defined energies. Evidence is presented that the five highest pulse height groups of charged particles consist of protons corresponding to defined energy states in Be^9. The observed proton energies are $10{\cdot}51 \pm 0{\cdot}03$, $8{\cdot}9 \pm 0{\cdot}2$, $8{\cdot}3 \pm 0{\cdot}2$, $7{\cdot}6 \pm 0{\cdot}1$, and $6{\cdot}1 \pm 0{\cdot}10$ MeV. In addition, groups of particles were barely discernible at the lower half of the pulse height scale used for the protons. Although these groups of particles are not positively identified, it seems relatively certain that they are α-particles corresponding to Li^6 in its various energy states. A special attempt to identify groups of deuterons failed, indicating that for some reason the formation of Be^9 is discriminated against in this reaction. A.

539.172.13

1206. New chain barium 126 – cesium 126. M. I. Kalkstein and J. M. Hollander. *Phys. Rev.*, **96**, *No.* 3, 730–4 (*Nov.* 1, 1954).

The neutron-deficient chain Ba^{126}–Cs^{126} has been produced from nitrogen-ion bombardments of indium in the 60 in. cyclotron, by the reaction $In^{115}(N, 3n)$. Studies have been made of this new chain with a 50-channel scintillation spectrometer, a scintillation coincidence spectrometer, and a time-of-flight mass spectrograph. Element assignments and genetic relations have been verified chemically, and the mass number assigned with the isotope separator. Ba^{126} decays principally by orbital electron capture with a half-life of $96{\cdot}5 \pm 2{\cdot}0$ minutes, and its daughter Cs^{126} is a positron emitter of $1{\cdot}6 \pm 0{\cdot}2$ minute half-life and electron capture branching of $18 \pm 4\%$. The decay of Cs^{126} proceeds by allowed transitions, $\sim 62\%$ to the ground state of Xe^{126} and $\sim 38\%$ to the first excited state at 385 keV. The positron spectrum has a maximum energy of $3{\cdot}8 \pm 0{\cdot}4$ MeV. On the basis of its decay properties, Cs^{126} appears to have a ground-state configuration of $(1+)$. A.

539.172.3

1207. Investigations on the reaction $^7Li(\gamma,\alpha)^3H$. P. Erdös, P. Stoll, M. Wächter and V. Wataghin. *Nuovo Cimento*, **12**, *No.* 5, 639–48 (*Nov.*, 1954).

The reaction was studied by exposing lithium-loaded nuclear emulsions to the radiation from a 31 MeV betatron. The cross-section as a function of γ-ray energy was measured and excited states of Li^7 found at 4·7, 5·5, 6·8, 8·3, 9 MeV. The first three levels have a relative intensity of $1 : 0{\cdot}75 : 0{\cdot}75$. The angular distribution analysis allows one to exclude certain possible values of the spin for the levels at 4·7, 5·5 and 6·8 MeV. The absolute value of the cross-section is obtained from the known $C^{12}(\gamma, 3\alpha)$ cross-section data. A selection rule which limits the number of low energy levels is discussed. A.

539.172.3

1208. The effect of nuclear compressibility on the nuclear photoeffect. J. M. Araújo. *Nuovo Cimento*, **12**, *No.* 5, 780–98 (*Nov.*, 1954).

A general two-fluid nuclear model is formulated for the case in which the nuclear energy density depends only on the local values of nucleon densities and not on their derivatives. Hydrodynamical equations, together with a generalized Laplace's equation, are derived taking account of compressibility. The energies corresponding to the lowest dipole oscillation modes are calculated for a few nuclei and compared with Jensen–Steinwedel's and Danos' results for the resonance energies for photon absorption. Better agreement with the experimental data is obtained, especially, as might be expected, for moderately heavy nuclei. A.

539.172.3

1209. Photodisintegration of helium. E. G. Fuller. *Phys. Rev.*, **96**, *No.* 5, 1306–9 (*Dec.* 1, 1954).

Helium gas at atmospheric pressure was irradiated with 26-, 29-, 32-, and 40-MeV bremsstrahlung spectra, The energy and angular distributions of the protons produced by the photodisintegration of He^4 were studied using nuclear emulsions to detect the charged particles. Angular distributions of the protons are fitted to a differential cross-section of the form $\sigma(\theta_{c.m.}) \sim (a/b) + \sin^2\theta_{c.m.}[1 + (\gamma/b)\cos\theta_{c.m.}]$. Over the energy range studied, the interference term may increase slowly with energy but is approximately constant ($\gamma/b = 0{\cdot}2 \pm 0{\cdot}1$); the isotropic term increases rapidly with energy from 0 to $0{\cdot}33 \pm 0{\cdot}2$ at a mean photon energy of 32·5 MeV. The (γ,p) cross-section reaches a peak value of about 1·8 mb at about 26 MeV.

$$\int_{20}^{40} \sigma dE = 0{\cdot}016 \pm 0{\cdot}005 \text{ MeV barns.}$$ A.

539.172.4

1210. Interpretation of the excitation of gamma-rays by 10 MeV neutrons. S. Hayakawa and K. Kikuchi. *Progr. theor. Phys.*, **11**, *No.* 6, 513–18 (*June*, 1954).

Gamma-rays from medium weight and heavy nuclei excited by 10 MeV neutrons are calculated on the basis of the compound nucleus formalism. Calculated γ-ray yield shows a fair agreement with the experimental data by Wakatsuki and Sugimoto, if the empirical temperature/mass-number relation is adopted. The competition of various emission processes is found to be important to account for the experiment. A.

539.172.4

1211. Relative cross-section of (n,p)-reaction in Al^{27} and Mg^{24}. S. K. Nandi and N. K. Saha. *Indian J. Phys.*, **28**, *No.* 8, 396–402 (*Aug.*, 1954).

Using fast neutrons from a 100 mg (Raα + Be)-source the relative cross-sections of the (n,p)-reactions in Al^{27} and Mg^{24} are determined by the method of

"threshold detector" following a previous work on S^{32} and P^{31}. Rates of β-disintegrations from Mg^{27} ($T = 10$ min) and Na^{24} ($T = 14{\cdot}8$ hr) formed in the reactions are measured under identical geometry. Methods for applying corrections for self-absorption of the β-rays in the active sample and due to other causes are discussed. The relative cross-sections with respect of S^{32} (n, p)-reaction are obtained as 0·11 for Al^{27} and 0·14 for Mg^{24}, showing a reasonably good agreement with the values obtained by Cohen. The importance of these results in interpreting the nuclear level-structure is discussed. A.

539.172.4

1212. Inelastic scattering of 14-MeV neutrons by lithium-7. D. L. Allan. Letter in *Nature* [*London*] **174**, 267 (*Aug.* 7, 1954).

This was investigated using a photographic plate loaded with natural lithium, searching for the α-particle and triton pairs of tracks from the reaction $Li^7(p,p')Li^{7*}(t)He^4$. From 167 selected events, levels in Li^7 were found at $4{\cdot}6 \pm 0{\cdot}25$ and $7{\cdot}5 \pm 0{\cdot}25$ MeV and a broad level between 6 and 7 MeV, in agreement with other workers. The reaction $Li^7(n,t)He^3(n)He^4$ gave evidence for what may be a new level in Li^7 at $9{\cdot}25 \pm 0{\cdot}25$ MeV. J. HUGHES

539.172.4

1213. Total cross section of Li^6 for neutrons. C. H. Johnson, H. B. Willard and J. K. Bair. *Phys. Rev.*, **96**, *No.* 4, 985–8 (*Nov.* 15, 1954).

The total cross-section of Li^6 for neutrons has been measured for neutron energies from 0·035 to 4·2 MeV. A resonance was observed with its maximum at $0{\cdot}255 \pm 0{\cdot}010$ MeV, which corresponds to 7·46 MeV excitation energy in Li^7. The observed width of the resonance at half-maximum is 100 keV. It is interpreted according to the nuclear dispersion theory as resulting from p-neutrons forming a state of total angular momentum 5/2. The cross-section rises gradually in the region from 1·5 MeV to 4·2 MeV. A.

539.172.4

1214. Neutron-capture cross sections by capture-gamma counting. E. Meservey. *Phys. Rev.*, **96**, *No.* 4, 1006–13 (*Nov.* 15, 1954).

A method is described for determining neutron capture cross-sections and locating capture resonances by capture-γ counting. Breit–Wigner parameters for the strong resonance in cadmium are determined to be $E_0 = 0{\cdot}177$ eV, $\sigma_{c0} = 7600$ barns, $\Gamma \doteq 0{\cdot}110$ eV. Resonances have been found in cadmium at 19 and 28 eV with evidence of unresolved resonances at about 100 eV and above; $\sigma_{c0}\Gamma \simeq 3$ barn-eV for the 19 eV level, and $\sigma_{c0}\Gamma^2 \simeq 9$ barn $(eV)^2$ for the 28 eV level. Comparison transmission measurements on cadmium show the capture-γ method to be quicker and more sensitive under some circumstances than transmission measurements for locating weak capture levels. Factors affecting the relative sensitivity of the two methods are discussed. A resonance was found in strontium at 3·58 eV, its strength $(\sigma_{c0}\Gamma^2)$ is approximately 8 barn-$(eV)^2$. Resonances were found in barium at energies of 25, 93 and 380 eV, with strengths $(\sigma_{c0}\Gamma^2)$ estimated to be 8, 90 and 550 barn $(eV)^2$, respectively. Measurements on a thick silver sample show that the method can be used to measure σ_c/σ_t through a resonance over a fairly large range of values of transmission and cross-sections. The strength of the 5·13 eV resonance in silver is determined to be $\sigma_{c0}\Gamma^2 = 345 \pm 30$ barn $(eV)^2$. A.

539.172.4

1215. Neutron resonances in the rare earth elements. V. L. Sailor, H. H. Landon and H. L. Foote, Jr. *Phys. Rev.*, **96**, *No.* 4, 1014–17 (*Nov.* 15, 1954).

The neutron cross-sections of the fifteen rare-earth elements (excepting $_{61}Pm$) have been measured in the energy range from 0·07 to ~20 eV with a crystal spectrometer. The resonances found are summarized in a table giving the resonant energies, E_0, and a qualitative value of the strength, $\sigma_0\Gamma^2$. For some cases, the isotope responsible for the resonance has been identified and is also listed. A.

539.172.4

1216. Slow neutron cross sections of gold, silver, indium, nickel, and nickel oxide. R. G. Allen, T. E. Stephenson, C. P. Stanford and S. Bernstein. *Phys. Rev.*, **96**, *No.* 5, 1297–305 (*Dec.* 1, 1954).

The total reflection and selective attenuation properties of mirrors for neutrons were used to obtain essentially higher order free reflections of a beam of reactor neutrons from a quartz crystal. An arrangement of mirror, crystal and sample, in series was used to measure the total cross-section of Au, Ag, In, Ni and NiO as a function of neutron wavelength over intervals in the region between 0·7 Å and 4·6 Å. The results on the strong absorbers Au, Ag and In were analysed into absorption and scattering contributions. The absorbers exhibited essentially the $1/v$ characteristic expected. The scattering and absorption cross-sections of Au, Ag and In are compared with previously reported values. For the strong scatterers Ni and NiO, the total scattering, ordered scattering and disordered scattering cross-sections, and the Debye temperature were derived from the energy dependence of the total cross-section. The ordered scattering cross-section per Ni nucleus was found to be $13{\cdot}1 \pm 0{\cdot}3$ barns. The capture and ordered elastic contributions were subtracted from the experimental curve of total cross-section v. energy. This residual scattering function of energy was compared to that theoretically expected from a Debye independent-oscillator model and the one-phonon incoherent scattering approximation of Kleinman. In the case of Ni, at the longer wavelengths, both models fit the data well, and at the shorter wavelengths, where multiple phonon processes occur, the independent oscillator model continues to fit the data. For NiO measurements fit the independent oscillator model at the shorter wavelengths, and lie above the values calculated from either model at the longer wavelengths. Additional measurements of the total cross-section of NiO as a function of temperature would be needed to attribute the difference between measured and calculated values at the longer wavelengths definitely to inelastic scattering processes. A.

539.172.4

1217. Determination of the absolute fission yield of Ba^{140} in thermal neutron fission of U^{235}. L. Yaffe, H. G. Thode, W. F. Merritt, R. C. Hawkings, F. Brown and R. M. Bartholomew. *Canad. J. Chem.*, **32**, *No.* 11, 1017–24 (*Nov.*, 1954).

The absolute fission yield of Ba^{140} in the thermal

neutron fission of U^{235} has been determined to be $(6{\cdot}32 \pm 0{\cdot}24)\%$. The reaction $B^{10}(n,\alpha)Li^7$ was used as a neutron monitor and the B^{10}/B^{11} ratio determined mass spectrometrically before and after neutron bombardment. The Ba^{140} disintegration rate was determined using 4π counting techniques. The half-life of La^{140} has been found to be $40{\cdot}31 \pm 0{\cdot}06$ hr. A.

539.172.4

1218. Fission yield fine structure in the mass region 99–106. D. R. Wiles and C. D. Coryell. *Phys. Rev.*, **96**, *No.* 3, 696–702 (*Nov.* 1, 1954).

Fission yield measurements were carried out in the mass region 99 to 106 to investigate previously postulated fine structure related to nuclear closed shells. Radiochemical data were obtained in this mass region in the fission reactions $U^{235}(n,f)$, $U^{238}(\gamma,f)$, $U^{235}(d,f)$ and $U^{238}(d,f)$ for the yields of Mo^{99}, Mo^{101}, Mo^{102}, Ru^{103}, Ru^{105} and Ru^{106}. Fine structure spikes were found in all reactions. It was found that the mass position of the spikes can be explained by the assumption that primary fission fragments with 82 neutrons or 50 protons and their complements have an enhanced yield as a result of selectivity in the fission process itself. Agreement was also found with two previously known reactions: $U^{233}(n,f)$ and Cm^{242} spontaneous fission. Fine structure is also predicted for several other fission reactions. A.

539.172.4

1219. Fine structure in the velocity distributions of slowed fission fragments. R. B. Leachman and H. W. Schmitt. *Phys. Rev.*, **96**, *No.* 5, 1366–71 (*Dec.* 1, 1954).

Fine structure is observed in the velocity distribution of U^{235} fission fragments that have been slowed by aluminium or nickel, but none is observed for unslowed fragments. Identification of this velocity fine structure with the fine structure in the fission mass yield confirms the influence of the 82-neutron shell in the fission act, as distinguished from its influence in post-fission neutron boil-off. The production of velocity fine structure by aluminium or nickel slowing is shown, by means of the measured range-velocity relation of fragments in these metals, to be the result of isobaric velocity bunching. The measured range-velocity relation of fragments in gold indicates no velocity bunching and therefore is consistent with the absence of velocity fine structure in measured velocity distributions of U^{235} fragments slowed in gold or platinum. The absence of velocity fine structure in the velocity distribution of U^{233} and Pu^{239} fragments slowed by aluminium is discussed. A.

539.172.4

1220. Thermal neutron distribution in the concrete shield of the JEEP. F. Alder and H. Klepp. *JENER Rep.*, *No.* 31, 3 *pp.* (1954).

539.172.4

1221. Criticality of normal-water natural-uranium lattices. R. Persson. *Nucleonics*, **12**, *No.* 10, 26–9 (*Oct.*, 1954).

The infinite multiplication constant (k_∞) was determined experimentally for different lattice spacings of 3 cm diameter natural U rods in light water. Two methods were used, one involving a measurement of the Laplacian and deduction of k_∞ using values of the migration area calculated by diffusion theory, the second method involving the integration of the neutron density over the whole core and reflector with and without the uranium present. The maximum value found for k_∞ was $0{\cdot}970 \pm 0{\cdot}015$. L. R. SHEPHERD

539.172.4

1222. Measurements on the neutron multiplication in a system of uranium rods and ordinary water. R. Persson. Letter in *Nature* [*London*] **174**, 265 (*Aug.* 7, 1954). See preceding abstract.

539.172.4

1223. Kinetics of circulating reactors at low power. J. A. Fleck, Jr. *Nucleonics*, **12**, *No.* 10, 52–5 (*Oct.*, 1954).

Circulation of fuel results in the removal of delayed neutron sources from the reactor core. The kinetic behaviour is investigated in detail in the case of uniform velocity of circulation at low power (i.e. no temperature effects), assuming a single delayed neutron group. The results obtained in this manner are shown to differ from those obtained by using the kinetic equations for a stationary fuel reactor with the delayed neutron fraction adjusted to allow for circulation. L. R. SHEPHERD

539.174 : 55

1224. On the accumulative effects at the earth's surface caused by thermonuclear explosions. C.-N. Martin. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 20, 1287–9 (*Nov.* 15, 1954) In French.

Possible effects of the hydrogen bomb are examined and it is concluded that certain chemical, climatic and radioactive changes are produced which are irreversible and these will cumulatively tend to alter certain of the planetary equilibria and in particular to alter the equilibrium of living processes.

J. M. HOUGH

ATOM AND MOLECULE BEAMS . MESONS NEUTRONS 539.18

539.18

1225. Possible existence of a new hyperon. Y. Eisenberg. Letter in *Phys. Rev.*, **96**, *No.* 2, 541–3 (*Oct.* 15, 1954).

Discusses an event observed in a stack of stripped emulsions. A particle, K_2, of estimated mass $940 \pm 200m_e$ comes to rest producing a 5-prong star with a visible energy release of 209 ± 4 MeV. On tracing K_2 back to its origin it was found that at one point it suffered a 10° deflection and measurements of grain density and mean scattering angle strongly suggest that at this point the K_2-particle was produced as a result of the decay in flight of a negative hyperon. The two following schemes are suggested as possibilities:

$$Y_1^- \rightarrow K_2^- + n + Q \quad (M[Y_1] \sim 2830m_e)$$
$$Y_1^- \rightarrow K_2^- + \Lambda^0 + Q \quad (M[Y_1] \sim 3160m_e)$$

H. ELLIOT

539.18

1226. Cloud-chamber evidence for a charged counterpart of the θ^0 particle. A. L. Hodson, J. Ballam, W. H. Arnold, D. R. Harris, R. R. Rau, G. T. Reynolds and S. B. Treiman. *Phys. Rev.*, **96**, *No.* 4, 1089–95 (*Nov.* 15, 1954).

A photograph obtained in a Wilson cloud chamber, operated in a magnetic field, shows the following

unusual event: A positive particle, produced in an interaction above the cloud chamber, decays in flight into a positive particle less massive than a K-meson. Four other lightly ionizing particles also originate from the decay point; these appear in the form of two small-angle pairs, each pair consisting of one positive and one negative particle. The observed momenta and ionizations are consistent with three of these four particles being either electrons or mesons; the fourth must be an electron. The event may be interpreted as the decay: $K^+ \rightarrow \binom{\pi^+}{\mu^+} + \pi^0 + Q$ MeV, followed by the decay of the π^0 meson into four electrons (a possible but hitherto unobserved mode of decay): $\pi^0 \rightarrow e^+ + e^- + e^+ + e^-$. This interpretation leads to a remarkable internal consistency of the data and is supported by the following experimental facts: (i) There is good overall transverse-momentum balance in two mutually perpendicular planes. (ii) If it is assumed that all the particles in the above group of four are electrons resulting from the decay of a neutral particle the mass of the latter, determined from energy-momentum balance, is $(255^{+15}_{10})m_e$, in good agreement with the known mass of the π^0-meson. (iii) A transformation to the rest system of the π^0-meson shows that in this frame the four electrons come off as two small-angle pairs travelling in opposite directions. This is the most probable configuration in the four-electron decay of a π^0-meson. The Q values calculated for the K^+ decay are: $Q(\pi^+, \pi^0) = 213^{+15}_{10}$ MeV and $Q(\mu^+, \pi^0) = (207^{+15}_{10})$ MeV. Comparison of the first Q values with that for the θ^0-particle $Q(\pi^+, \pi^-) = 214 \pm 5$ MeV, suggests that the unstable meson observed in this event and designated phenomenologically above as a K^+-meson may be a charged counterpart of the θ^0-particle. This interpretation may explain at least some of the cases, observed by other workers, in which γ-rays appear to be associated with S-particles. Other possible interpretations of the event are considered. A.

539.18

1227. Ionization energy loss of mesons in a sodium iodide scintillation crystal. T. Bowen. *Phys. Rev.*, **96**, *No.* 3, 754–64 (*Nov.* 1, 1954).

The response of a thallium-activated sodium iodide crystal to high-energy charged particles passing through the scintillator has been investigated. Pions and muons produced by the Chicago 450 MeV cyclotron have been used to cover energies ranging from 61 MeV (pions) to 245 MeV (muons). Sea-level cosmic-ray muons have been used to cover energies from 200 MeV to greater than 2 BeV. At each energy, the most probable energy loss is determined from the pulse-height distribution, making use of Po–Be 4·44 MeV γ-rays for an energy calibration. The distributions from cyclotron data are found from the density variations on photographs of the superposition of many pulses appearing on an oscilloscope. Because the cosmic-ray counting rate is low, each pulse is individually photographed and measured. The results for energies below the occurrence of the minimum in ionization indicate good agreement with the probable energy loss as given by the Bethe–Bloch formula. Beyond the minimum the probable loss is in fair agreement with Sternheimer's calculations for sodium iodide, rising slightly more rapidly than predicted to the Fermi plateau. A.

539.18

1228. Total cross sections for negative and positive pions in hydrogen and deuterium. J. Ashkin, J. P. Blaser, F. Feiner, J. G. Gorman and M. O. Stern. *Phys. Rev.*, **96**, *No.* 4, 1104–15 (*Nov.* 15, 1954).

External meson beams, ranging in energy from 135 MeV to 260 MeV for the π^-, and 135 MeV to 198 MeV for the π^+, have been used for the measurement of total cross-sections by an attenuation experiment using liquid hydrogen as well as CH_2 and C as absorbers. Possible errors introduced by contamination of the π^+ beam by protons have been eliminated by use of time-of-flight and pulse-height discrimination. The corrected cross-sections for π^--mesons in hydrogen rise from 47 mb at 133 MeV to a maximum of about 66 mb near 180 MeV and fall thereafter to 38 mb at 258 MeV, with typical uncertainties of $\pm 5\%$. The cross-sections for π^+-mesons rise from 122 mb at 128 MeV to around 200 mb between 170 MeV and 196 MeV, with accuracy comparable to that for the π^--mesons except for the very high energies where the beams are of low intensity. The π^+ cross-sections follow very well the curve representing three times the total π^- cross-section, indicating that in the measured energy range the dominant interaction between pion and nucleon occurs for total isobaric spin $I = \frac{3}{2}$. Comparison of the π^- cross-section with $(8/3)\pi\lambda^2$ supports the idea that the particular angular momentum state $J = \frac{3}{2}$, $L = 1$ (for $I = \frac{3}{2}$) is especially prominent in the scattering. The total cross-sections for π^+- and π^--mesons interacting with deuterium have also been measured by comparing the transmissions of D_2O and H_2O cells. Within the accuracy, the π^+ and π^- total cross-sections are equal, consistent with the principle of charge symmetry. The total scattering cross-section of deuterium is less than but of the same order of magnitude as the sum of the hydrogen cross-sections for π^+ and π^-. A.

539.18

1229. Some examples of the decay of V-particles. G. E. Chikovani, Z. Sh. Mandzhavidze, L. D. Gedevanishvili and M. F. Bibilashvili. Letter in *Zh. éksper. teor. Fiz.*, **26**, *No.* 4, 505–6 (1954) In Russian.

In 1800 photographs taken at 3900 m with a cloud chamber in a field of 6800 gauss under 20 cm Pb, and activated by systems of counters responding to penetrating showers, 4 V-events were found. The 1st is the decay of a $2400 \pm 200m_e$ V^0 into a proton (1·44 BeV/c) and negative meson (0·4 BeV/c). The coefficient $\alpha \equiv (p_+^2 - p_-^2)/p_0^2$ is 0·61. The 2nd is probably $V^0(667 \pm 70m_e) \rightarrow \pi^+(0{\cdot}12\ \text{BeV/c}) + \pi^-(0{\cdot}34\ \text{BeV/c})$ with $\alpha = -0{\cdot}51$. The other 2 cases show changes of direction of 120° in a 0·4 BeV/c negative, and 36° in a 0·63 BeV/c positive track, respectively, and can be interpreted as decays of V^+.

W. J. Swiatecki

539.18

1230. Radiative correction to the lifetime of the π^0-meson. A. D. Galanin and V. G. Solov'ev. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 1(7) 112–14 (1954) In Russian.

An alternative method is given for deriving the

additional term L' in the Lagrangean corresponding to a ps. scalar meson-nucleon interaction [compare Abstr. 2014 (1950), 5082 (1951)]. Using Feynman's method the radiative correction is worked out. The lifetime becomes $\tau^{-1}=\pi^{-2}(g^2/\hbar c)(e^2/\hbar c)^2(\mu/4m)^2(\mu c^2/\hbar)$ $[1+(7/4\pi)(g^2/\hbar c)]$, where μ = meson, m = nucleon mass. W. J. SWIATECKI

539.18

1231. Some regularities of the decay of mesons into three particles. M. I. PODGORETSKIĬ AND I. L. ROSENTAL'. *Zh. éksper. teor. Fiz.*, **27**, *No.* 2(8) 129–34 (1954) In Russian.

The distribution of secondary particles is taken to be determined by the available volume in phase space. The distribution with energy and angle of the secondary particles is calculated in the extreme relativistic and non-relativistic cases, in the laboratory system. The non-coplanarity of the particles is discussed in the case of the τ-meson decaying into π's.

G. E. BROWN

539.18

1232. An abnormal τ-meson decay. R. R. DANIEL AND Y. PAL. *Proc. Indian Acad. A*, **40**, *No.* 3, 114–18 (*Sept.*, 1954).

An unusual example of a τ^+-meson decay in nuclear emulsions is described. From the measurements made on the momenta and direction of the three π-mesons emitted, the event is interpreted as a decay of a τ-meson according to the scheme: $\tau^+ \rightarrow \pi^+ + \pi^+ + \pi^- + \gamma + Q$. A.

539.18 : 778.34

1233. Life time measurements of unstable charged particles of cosmic radiation using emulsions. E. AMALDI, C. CASTAGNOLI, G. CORTINI AND C. FRANZINETTI. *Nuovo Cimento*, **12**, *No.* 5, 668–76 (*Nov.*, 1954).

Two different procedures are described which both allow the determination of the mean life of charged unstable particles whose tracks are observed in nuclear emulsions. The first procedure is based on the method of "maximum likelihood." The second procedure is based on the use of the so-called "residual time." This time is defined as follows: Let us consider a particle which decays in flight in the plate, with a velocity β_d at an instant t_0. If it has not decayed it would have been brought to rest in the emulsion at a time t_0. The time interval $t_d - t_0$ is the "residual time." The combination of the two methods reduces the influence of experimental bias of both geometrical and kinematical origin. The application of these methods to the case of hyperons allows one to establish the following limits to their mean life: $3\times10^{-10} \geqslant \tau \geqslant 0{\cdot}5\times10^{-10}$ sec. A.

539.18

1234. On the γ-rays associated with S-particles. M. ANNIS, L. TAFFARA AND B. DEQUAL. Letter in *Nuovo Cimento*, **12**, *No.* 5, 813–14 (*Nov.*, 1954).

The anomalous decay of an S-particle into a μ-meson, a neutrino and a γ-ray is calculated from Eguchi's formula [Abstr. 4626 (1952)]. In about one case in a hundred a γ-ray of more than 5 MeV may be emitted. P. T. MATTHEWS

539.18

1235. Interaction of a negative heavy meson. J. E. NAUGLE, E. P. NEY, P. S. FREIER AND W. B. CHESTON. *Phys. Rev.*, **96**, *No.* 5, 1383–5 (*Dec.* 1, 1954).

An interaction caused by a stopping heavy meson has been observed in emulsion. One of the four particles emitted in the interaction is interpreted as a nuclear fragment with a Λ^0 attached. The subsequent mesonic decay of this bound Λ^0 leads to a Q of $34{\cdot}2 \pm 0{\cdot}9$ MeV. The measured mass of the heavy meson is $1010 \pm 200m_e$. The visible kinetic energy released in the interaction it causes is 50 ± 8 MeV. A.

539.18

1236. A statistical method for determining the masses of unstable neutral particles and their decay products. G. E. CHIKOVANI. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 1, 110–12 (1954) In Russian.

Formulae are derived which enable the masses of a neutral primary and of the two (pos. and neg.) secondaries to be determined solely from the momenta components of the latter, without assumptions about the decay or estimates of ionization. An application to 16 cases of V_1^0 decay taken from the 22 quoted by Armenteros *et al.* [Abstr. 7956 (1953)] gives $m(V_1^0) = (1996 \pm 150)m_e$, $m_+ = (1606 \pm 20)m_e$, $m_- = (241 \pm 70)m_e$ if no assumptions are made about m_+, and $m(V_1^0) = (2196 \pm 3)m_e$, $m_- = (280 \pm 28)m_e$ if m_+ is assumed to be a proton. W. J. SWIATECKI

539.18 : 778.34

Photo-electric mass determinations in nuclear emulsions. *See Abstr.* 1435–7

539.18

1237. The transformation of 2 photons into a π^0-meson and the production of π^0-mesons in the Compton effect. A. YA. TEMKIN. Letter in *Zh. éksper. teor. Fiz.*, **26**, *No.* 5, 645–6 (1954) In Russian.

Using an interaction Lagrangean consisting of the product of the ψ-field of a π^0-meson and $(\partial A/\partial t)\text{curl } A$ (A = electromagnetic vector potential), the cross-section for $2\gamma \rightarrow \pi^0$ is found to be $\sim10^{-27}$ cm^2 for photons with a wavelength twice the meson Compton wavelength. The threshold for $\gamma + e \rightarrow e' + \pi^0$ is $\sim$21 BeV, and at 22 BeV the cross-section is $\sim10^{-46}$cm^2. W. J. SWIATECKI

539.18

1238. Elastic photoproduction of π^0 mesons from helium. E. L. GOLDWASSER, L. J. KOESTER, JR AND F. E. MILLS. Letter in *Phys. Rev.*, **95**, *No.* 6, 1692–4 (*Sept.* 15, 1954).

"Elastic" denotes the process $h\nu + \text{He}^4 \rightarrow \pi^0 + \text{He}^4$ which is observed at γ-energies of 150 and 155 MeV before π^0 production accompanied by the breaking up of He^4 occurs. Measurements at higher energies are also made. G. E. BROWN

539.18

1239. Matrix elements for double pion photoproduction. R. GATTO. Letter in *Nuovo Cimento*, **12**, *No.* 4, 568–70 (*Oct.*, 1954).

The implications of charge independence for double and multiple pion photoproduction.

P. T. MATTHEWS

539.18

1240. Double pion production and the nature of pseudoscalar coupling. P. BOCCHIERI AND G. FELDMAN. *Phil. Mag.*, **45**, 1145–53 (*Nov.*, 1954).

A perturbation calculation for single and double

pion production is carried out for pseudoscalar, symmetric meson theory at energies in the Birmingham range (about 1000 MeV). It is found that the γ_5 nature of the coupling does not favour double over single production and that, in fact, a large coupling constant would be required to explain a large double to single ratio. A.

539.18 : 539.172.13

1241. Neutral pion-deuteron production in 400-MeV π-p collisions. R. A. SCHLUTER. *Phys. Rev.*, **96**, *No.* 3, 734–42 (*Nov.* 1, 1954).

The reaction $n + p \rightarrow d + \pi^0$ has been studied in a high-pressure hydrogen-filled diffusion cloud chamber. A total of 102 deuterons were identified by a technique of ionization measurement in conjunction with momentum measured in the 10 500-gauss magnetic field. From the laboratory deuteron angle and momentum, the pion angle and the incident neutron energy can be deduced with good resolution, provided the pion is emitted backward in the centre-of-mass system. Proton recoils were observed simultaneously, from which the incident neutron flux and energy spectrum were determined. The energy spectrum is centred at 400 MeV with a spread of ± 25 MeV. From 52 events occurring in the backward direction the angular distribution of pion emission was found to be consistent with $(0{\cdot}28^{+0{\cdot}26}_{-0{\cdot}14} + \cos^2\bar{\psi}_\pi)$, where the limits include 70% of the probability and $\bar{\psi}_\pi$ is the pion angle in the centre-of-mass system. The observed excitation function and total cross-section determined from 60 events is consistent with $(0{\cdot}47 \pm 0{\cdot}08)\eta^3$ millibarn, where η is the centre-of-mass pion momentum in rest mass units. These results agree, within the accuracy of the measurements, with the prediction of charge independence that the ratio of this reaction to $p + p \rightarrow d + \pi^+$ should be $\frac{1}{2}$. Eight cases of internal conversion of the neutral pion were seen, four accompanied by deuterons and four by protons, the latter giving evidence on neutral pion creation with unbound final nucleons. A.

539.18

1242. Search for the production of μ-meson pairs by a 345-MeV synchrotron beam. B. T. FELD, A. JULIAN, A. C. ODIAN, L. S. OSBORNE AND A. WATTENBERG. *Phys. Rev.*, **96**, *No.* 5, 1386–90 (*Dec.* 1, 1954).

Observations made at 45° and 90° to a 345 MeV bremsstrahlung beam failed to indicate the production of pairs of μ^+-μ^--mesons from targets of Be and Al. From the run on Be at 45°, $\sigma(\mu \text{ pair}) < (4\times10^{-32}/16\pi^2)$ cm^2 (steradian)$^{-2}$ proton^{-1}. This upper limit is twenty times the value predicted by the Bethe–Heitler theory for a purely electromagnetic interaction. The result would seem to preclude any interaction between pairs of μ-mesons and nucleons which is as large as 10^{-3} of the strength of the interactions of π-mesons and nucleons. A.

539.18

1243. Semi-phenomenological theory of the interaction of π-mesons with nucleons. I. The scattering of π-mesons by nuclei. I. E. TAMM, YU. A. GOL'FAND AND V. YA. FAĬNBERG. *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 649–67 (1954) In Russian.

The basis of the approach [cf. Abstr. 77 (1954)] is the assumption of a nucleon of mass M which can exist in an excited isobaric state with ordinary and isotopic spins $\frac{3}{2}$ and mass $M + \Delta$. The interaction of a pion with the nucleus is described by 3 constants: ps. vector coupling constant g/(pion mass), ps. scalar coupling const. g' and a constant g_1 determining the probabilities of absorptive or radiative transitions between the 2 states of the nucleon. The nucleon (as well as the pion) are treated relativistically, which narrows down appreciably the arbitrariness in the formulation of the basic equations and turns out to be quantitatively important even at relatively low pion energies (~50 MeV). The matrix elements for the scattering are worked out to order g^2, g_1^2, the effect of higher orders being represented phenomenologically by the isobaric state. Formulae for the scattering phases and cross-sections are derived. Comparison with experiments with π^+, π^- and $\pi^- \rightarrow \pi^0 \rightarrow 2\gamma$ at $\theta_{\text{c.m.}} = 56°$, 104°, 145° and pion energies 40-260 MeV (lab.) and the corresponding total cross-sections from 40–450 MeV [Anderson *et al.* (1952), Fermi *et al.* (1952), etc.], can be fitted with $\Delta = 2{\cdot}1 \times m_\pi$ and either (*a*) $g^2 = 0{\cdot}20$, $g'^2 = 5{\cdot}5g^2$, $g_1^2 = 0{\cdot}13$ or (*b*) $g^2 = 0{\cdot}10$, $g'^2 = 4{\cdot}0g^2$, $g_1^2 = 0{\cdot}12$. The probability of K-capture of a π^--meson by a nucleus is estimated using the above constants to be $0{\cdot}46\times10^{15}$ or $0{\cdot}14\times10^{15}$ sec^{-1} respectively. The above phenomenological approach should make it possible to deduce nuclear forces at distances where heavier mesons are not important. W. J. SWIATECKI

539.18

1244. Scattering of π-mesons on nucleons in the theory of damping. G. F. ZHARKOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9) 296–306 (1954) In Russian.

The calculation is carried to second order with an adjustable mixture of ps and pv couplings. The theory gives maxima in the cross-section for scattering of both π^+'s and π^-'s, but the results disagree quantitatively with experiment, except, possibly, in the region $E \sim 40$ MeV, which is high enough for Coulomb effects to be neglected and low enough for the formation of the isobaric state may be neglected. Theoretical angular distributions are given in this region. G. E. BROWN

539.18

1245. Magnetic effects in the scattering of muons by nuclei. R. GATTO. *Nuovo Cimento*, **12**, *No.* 5, 613–18 (*Nov.*, 1954).

In connection with recent experiments on the scattering of μ-mesons by nuclei the effect of the anomalous magnetic moment of the incident muon and of the distribution of currents in the nucleus have been evaluated. The results are for non-polarized beams incident on non-polarized nuclei. At relatively large angles the cross-sections depend sensitively on the way in which the charges and currents are distributed in the nucleus. A.

539.18

1246. Measurement of Coulomb interference in 113-MeV π^+-p scattering. J. OREAR. *Phys. Rev.*, **96**, *No.* 5, 1417–20 (*Dec.* 1, 1954).

Pion-proton scatterings with a small angle cutoff of 12·5° in the centre-of-mass system were detected using the area-scanning, nuclear-emulsion technique. Ilford G5 plates 600 microns thick were exposed to a

flux of $4{\cdot}4\times10^5$ mesons/cm² in the 122 MeV π^+ beam of the Chicago cyclotron. Various checks indicated a scanning efficiency greater than 90% for scatterings on the hydrogen content of the emulsion between 12·5° and 160°. Out of a total 420 hydrogen events only two scatterings were less than 20°. The data when analysed according to the two possible sets of signs of the phase shifts give a strong preference for destructive interference, i.e. attractive $p_{\frac{3}{2}}$ interaction. In this case the maximum likelihood solution is $\alpha_3 = -(10{\cdot}9 \pm 2)°$, $\alpha_{33} = (27{\cdot}0 \pm 1{\cdot}5)°$ and $\alpha_{31} = -(3{\cdot}2 \pm 1)°$ for the *s*- and *p*-wave phase shifts with no definite indication of a *d*-wave component. The total nuclear cross-section is (79 ± 5) millibarns. The mean energy of pions in the emulsion is (113·0 ± 1·6) MeV as determined from 33 events where the proton stops in the emulsion. A.

539.18

1247. On the nature of τ-mesons and V_2^0-particles. I. S. Shapiro. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 2(8) 257–8 (1954) In Russian.

The consequences of assuming the $\tau^\pm$ and V_2^0-mesons to form a triplet in isotopic spin space are discussed. These are: (1) both particles must be vector (with parity −1) or be of higher spin; (2) the $\tau^\pm$-meson can decay into $\pi^\pm + \pi^0$; (3) the V_2^0 is stable with respect to decay into two π^0's. G. E. BROWN

539.185

1248. Neutrino recoil spectrometer. Investigation of A^{37}. O. Kofoed-Hansen. *Phys. Rev.*, **96**, *No.* 4, 1045–50 (*Nov.* 15, 1954).

A neutrino recoil spectrometer has been constructed. The recoil momentum and the charge distribution of the recoil ions from the *K*-capture of A^{37} has been studied. The results are: neutrino energy, 812 ± 8) keV; recoils of charge 1, (26 ± 3)%; recoils of charge 2, (13 ± 4)%; recoils of charge 3, (38 ± 4)%; recoils of charge 4, (18 ± 2)%; recoils of charge 5, (4 ± 1)%; and recoils of charge 6, (1 ± 1)%. Furthermore, the average momentum of the electrons emitted during the ionization of the recoils is 69 ± 1 gauss cm. The most energetic Auger electrons have a momentum of 162 ± 4 gauss-cm and they occur in (65 ± 5)% of the decays. A.

539.185

1249. Upper limit on the neutrino magnetic moment. C. L. Cowan, Jr, F. Reines and F. B. Harrison. *Phys. Rev.*, **96**, *No.* 5, 1294 (*Dec.* 1, 1954).

A liquid scintillation detector and neutrinos from a fission reactor were employed to set a new upper limit of 10^{-7} Bohr magnetons for the neutrino magnetic moment. A.

539.185

1250. Diffusion parameters of thermal neutrons in water. G. von Dardel and N. G. Sjöstrand. *Phys. Rev.*, **96**, *No.* 5, 1245–9 (*Dec.* 1, 1954).

A method is described for the determination of neutron diffusion parameters by measurements of the decay of thermal neutrons in a finite moderator with a pulsed-neutron source and a time analyser. In the theory for the method one takes into account the "diffusion cooling" effect, which decreases the temperature of thermal neutrons below the temperature of the moderator. Measurements are reported on a cylindrical geometry, involving between 1 and 4 litres of distilled water. Analysis of the result yields a value of 0·333 ± 0·003 barns for the neutron-proton capture cross-section, in good agreement with other measurements, and $(36\,340 \pm 750)[1 - (0{\cdot}20 \pm 0{\cdot}04)\kappa_0^2]$ cm²/sec for the diffusion constant of thermal neutrons in water. The term involving the "buckling" κ_0^2 of the geometry is due to the diffusion cooling effect. The value of the diffusion constant for $\kappa_0^2 = 0$ leads to a value for the diffusion length in excellent agreement with the result of other measurements. The diffusion cooling effect is larger by a factor of 3·5 than the theoretical value, calculated for the model of a monatomic gas. A.

539.185

1251. Scattering of 80°K-neutrons by CH_3OH and CH_3I molecules. J. A. Janik. *Acta phys. Polon.*, **13**, *No.* 3, 167–73 (1954).

Experiments on the scattering of slow neutrons by rigid molecules of a liquid show that the theory of Sachs and Teller may be applied to many liquids. The cross-section for the scattering of slow neutrons is then independent of the energy of the neutrons. This was verified for the CH_3I-molecule using 300°K- and 80°K-neutrons. Measurements of the cross-section for CH_3OH-molecules give the value $(180 \pm 6)\times10^{-24}$ cm² for 300°K-neutrons and $(227 \pm 10)\times10^{-24}$ cm² for 80°K-neutrons. The cross-section obtained from the theory of Sachs and Teller is 247×10^{-24} cm². These results are interpreted as the influence of torsional oscillations between OH and CH_3 groups in the CH_3OH-molecule in agreement with the theory given by W. Kolos. A.

539.185

1252. Neutron-proton scattering at 91 MeV. R. H. Stahl and N. F. Ramsey. *Phys. Rev.*, **96**, *No.* 5, 1310–15 (*Dec.* 1, 1954).

The angular distribution of neutrons scattered by protons has been measured for centre-of-mass scattering angles between 60° and 180°. The effective neutron energy was 91 ± 1 MeV. A liquid hydrogen scatterer and plastic scintillation proton counters were used. The experimental results are in good agreement with previous experiments at this energy. A.

539.185

1253. Neutron spin from magnetic resonance experiment. C. P. Stanford, T. E. Stephenson and S. Bernstein. *Phys. Rev.*, **96**, *No.* 4, 983–4 (*Nov.* 15, 1954).

The magnetic resonance type of experiment used for the measurement of the gyromagnetic ratio of the neutron has been extended to give a demonstration of the neutron spin. The spin ($\frac{1}{2}$) is demonstrated uniquely by the measured transition probability as a function of the amplitude of the oscillating magnetic field. A.

539.185.7

1254. On the neutron spectrum for $v^{-\alpha}$ absorption cross section. B. Davison and M. E. Mandl. *Proc. Phys. Soc.* [*London*] *A*, **67**, *Pt* 11, 967–72 (*Nov.*, 1954).

An approximate expression is found for the neutron absorption energy spectrum in an infinite medium consisting of atoms of mass number *M*, for which scattering is assumed isotropic in the centre-of-mass

system and $\sigma_a/\sigma_{sc} \propto v^{-\alpha}$, where α is a positive constant. The accuracy of certain useful types of integral over the resulting spectrum is examined. A.

STRUCTURE OF SOLIDS 539.2

539.215.08

1255. Survey of the relative motion of particles and fluids. P. G. W. Hawksley. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 1–S 5 (1954).

The relative motion of particles and fluid is discussed in terms of the hydrodynamic interference between particles in a suspension, which ranges from a small effect in the dilute suspensions used in particle size analysis to a decisive magnitude in the permeability of packed beds of particles. The behaviour of clouds of particles, sedimentation and viscosity of concentrated suspensions, hindered settling and fluidization are briefly mentioned. A.

539.215.08

1256. The effective viscosity of suspensions. G. J. Kynch. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 5–S 11 (1954).

A method is given for solving exactly the equations for slow, steady flow of an incompressible fluid containing a number of particles. These equations have been solved statistically for a suspension of spheres at low concentrations, and it is shown that Einstein's formula is not justified at concentrations above 1%. The procedure for larger concentrations is suggested, though not completed. A.

539.215.08

1257. The terminal velocity and structure of airborne aggregates of microscopic spheres. V. Timbrell. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 12–S 16 (1954).

The terminal velocity of aggregates of spheres is determined by means of a dust sampling instrument which deposits them at sites on a collecting plate related to their terminal velocity; the size and relative positions of the spheres in an aggregate are determined microscopically. A test is applied to decide whether an aggregate examined was airborne in the same state or formed by juxtaposition of two or more airborne units at the same site. The free-fall orientation of an aggregate can be inferred from its orientation on the collecting plate. Results are given for the relationship between the Stokes' diameter of a doublet and the size of the components. A.

539.215.08

1258. Dust shadows below a cylinder containing a suction orifice and deposition of particles upon the cylinder. C. N. Davies and V. Peetz. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 17–S 20 (1954).

A study is made of the aspiration of dust, suspended in an ideal fluid, into a bulky sampling head with an orifice in the top. The behaviour of the particles is characterized by the value of a parameter k which is proportional to the square of the particle size divided by the rate of suction. When k is greater than 2, gravity governs the movement of the particles and when it is less than $1/(3 + 2\sqrt{2})$ the influence of suction predominates. For values exceeding $1/(3 + 2\sqrt{2})$ a shadow free from dust extends to infinity below the head and particles settle on the top. For smaller values of k there is no deposition on the head and the shadow area is finite. An indication is given of the way in which the system could be employed for particle size analysis by selective sampling. A.

539.215.08

1259. A comparison of methods for particle size analysis. B. A. Jarrett and H. Heywood. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 21–S 28 (1954).

The research was undertaken to make comparative tests on equipment for particle size analysis with the special object of devising methods suitable for rapid routine analyses by sedimentation. A special test dust, having a controlled grading, was used for the comparative tests. The authors' recommendations for suitable methods of size analysis are given, with the probable degree of error and the range of particle size to which the various methods are applicable. A.

539.215.08

1260. Theory of size classification of airborne dust clouds by elutriation. W. H. Walton. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 29–S 39 (1954).

Particle size classification systems are considered of the type in which an airborne dust cloud is drawn at a low velocity (so that inertial forces are negligible) through a vertical or horizontal duct (elutriator) in which the larger particles are removed by gravitational settlement. It is shown that within such a system the concentration of particles of given falling speed f remains constant along any (particle) flow tube; tubes coming from the open cloud contain particles at the original cloud concentration, whereas those originating from the underside of an impervious surface are empty. It follows that if particles are drawn upwards on to a horizontal inverted filter immersed in the cloud, there being a uniform vertical air velocity v immediately beneath the filter surface, then the number of particles collected will be a fraction $1 - (f/v)$ of those originally contained in the sampled air. The addition of a vertical elutriator tube beneath the filter has no effect on the selectivity, in particular the velocity profile within the tube is of no consequence and it is not possible to obtain a sharper cut than that indicated by the above formula. If the elutriator is fitted with a convergent upper section before the filter, the sharpness of the classification will be diminished. A similar classification of particles can be obtained by drawing the cloud through a horizontal channel. In this case the fraction passing, of falling speed f, is $1 - (fA/Q)$ where Q is the volume flow rate and A is the horizontally projected floor area of the duct. The shape of the duct and the vertical air velocity profile within it are immaterial provided that Q/A is constant for all air streams. Horizontal elutriation systems of this type are more convenient to use in practice than vertical systems since the dimensions can be much smaller for a given throughput and the penetrating cloud can be collected on a filter or other device of a

small area. They provide a standard means of classifying airborne dust in sampling, which is suitable for a wide range of requirements. A.

539.215.08

1261. Electroviscosity in dilute heterodisperse suspensions. G. A. H. Elton and F. G. Hirschler. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 60–S 63 (1954).

It is shown that the ionic content of the suspending medium is of importance in determining the velocity of sedimentation of particles in the micron size range. Calculations are made for the effect of electroviscosity on the rate of separation of particles by the sedimentation method, and it is concluded that in extreme cases it may not be possible to separate particles differing in size by up to 25%. The elimination of the electroviscous effect in sedimentation analysis is discussed, and it is shown that the effect can generally be eliminated by carrying out the sedimentation in a moderately concentrated electrolyte solution. A.

539.215.08

1262. The shape of ground petroleum coke particles. T. Beirne and J. M. Hutcheon. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 76–S 81 (1954).

The variation with size of particle shape and other particle characteristics has been determined for a petroleum coke ground in standard equipment. Novel methods have been developed for particle counting and projected area measurement. Existing methods for particle density measurement have been examined and modified. A.

539.215.08

1263. The significance and application of shape factors in particle size analysis. W. H. M. Robins. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 82–S 85 (1954).

By use of a new method for measuring the thickness of individual sub-sieve particles with the optical microscope and being able to measure the dimensions of their projected images as well, the surface and volume shape factors of the particles can be calculated. An expression can be derived for the ratio of the particle's projected diameter to its Stokes' diameter in terms of these factors. Results of the examination of coal-dust particles revealed a large variation in the shape factors between particles, which should also be found for particles of other materials. It is shown that in the application of shape factors to the correlation of results obtained by different methods for particle size analysis, the variation of these factors should be taken into account. The method of application has been devised for use when comparing results of the microscope method with those of sedimentation methods, both gravimetric and light extinction. This method has been compared with the normal way in which only the average shape factor is applied. Differences occurred which could account for some of the past difficulties when the correlation of the sizing methods was attempted. The largest particles of a sub-sieve fraction of a powder seen under the microscope have shape factors different from those of the smaller sizes. A.

539.215.08

1264. The terminal velocity and size of airborne dust particles. V. Timbrell. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 86–S 90 (1954).

An instrument for sampling airborne particles is briefly described, in which the particles are classified according to their terminal velocities and deposited on a glass plate in a continuously graded sample. It can be employed to determine: (i) the Stokes' diameter-frequency distribution; (ii) the variation of mean projected diameter for a constant value of Stokes' diameter, and the variation of the Stokes' diameter for a constant value of mean projected diameter; (iii) the mean weight of particles of given Stokes' diameter. A.

539.215.08

1265. The relation between free falling speed and particle size of airborne dusts. R. J. Hamilton. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 90–S 95 (1954).

The relation between the particle size, as measured microscopically, and the free-falling speed of some industrial dusts—coal, rock, cotton and asbestos—has been studied with the aid of the Conifuge. It was found that particles of a given falling speed cover a wide range of sizes, the relation between the two parameters differing with various dusts, and even with different types of coal. The result is significant in relation to the assessment of health hazard of industrial dusts, since these are conventionally classified by microscope sizing, whereas respirability is a function of falling speed. A.

539.215.08 : 519.2

1266. Survey of the automatic counting and sizing of particles. W. H. Walton. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 121–S 125 (1954).

A simple account is given of the basic principles employed in automatic counting and sizing devices and of some of the difficulties encountered. A.

539.215.08 : 519.2

1267. Theory of particle sizing and counting by track scanning. P. G. W. Hawksley. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 125–S 132 (1954).

A theoretical relation is developed between the number and size distribution of particles dispersed in a plane field of view and the number of particles intercepted by a scanning track drawn across the field; it is shown that the number of oversize particles per unit area can be obtained from observations of the numbers intercepted by tracks of different widths. It is shown also that the usual methods of counting are special cases. A.

539.215.08 : 519.2

1268. Some fundamental aspects of particle counting and sizing by line scans. J. W. Phillips. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 133–S 137 (1954).

Some of the simpler ways of using line scans are noted, particularly with reference to counting and sizing particles which approach the limits of optical resolution. A general treatment relating derivable

information to observed data of frequency of interception of particles by line scans and combinations of line scans is given, and it is shown that to achieve a desirable accuracy a large aperture must be used and the presence of particles which do not fill the whole aperture must be recognized; this is best done by using an aperture composed of a line of independent probes so that the field is scanned as with a comb. Other methods, favoured at present, which depend on the use of apertures or probes whose size and position must be known accurately, cannot realize the potential and desirable accuracy of counting and sizing owing to limits set by optical resolution. Estimates are made of the increased counts required in statistical methods and also of the relative merits of criteria of association of signals in methods where particles are assessed individually. A.

539.215.08 : 535.43

Light scattering methods of particle size analysis. *See Abstr.* 874–6

539.215.08 : 535.824.1

1269. Factors in the design of a microscope eyepiece graticule for routine dust counts. R. J. Hamilton, J. F. Holdsworth and W. H. Walton. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 101–S 105 (1954).

The limitations of existing microscope eyepiece graticules for use in routine dust counting work and the problems of determining the geometrical form and physical dimensions of a graticule for use with commercial microscope equipment are discussed. Comparison is made of the consistency and accuracy obtainable with three types of graticule: the Patterson-Cawood, a simplified globe and circle type and a parallel line graticule. The simple globe and circle graticule described has been taken into general use in the National Coal Board. A.

539.215.08 : 535.826.9

1270. Some methods of dispersing difficult powders. M. G. Harwood. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 193–S 194 (1954).

Methods are described for making suitable microscopic slides for particle size distribution analysis on two types of powders found difficult to do by the usual methods. One involves the use of electrical charges to repel the particles and fixing the aqueous suspension with a gelatine-coated slide to overcome Brownian movement. The other, for magnetic materials, involves heating the sample to a temperature above the Curie point, dispersing and fixing them on a slide before they cool. A.

539.215.08 : 535.827.2

1271. Inter-laboratory checks on the counting of coal dust particles on thermal precipitator slides. J. F. Holdsworth, F. H. Price and R. C. Tomlinson. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 96–S 101 (1954).

Describes experiments carried out by the Medical Research Council and the National Coal Board to compare the results obtained by observers in different laboratories when counting coal dust particles on thermal precipitator slides. Serious differences were discovered which have now largely been removed within the National Coal Board by the institution of regular inter-laboratory checks. These checks have also aided the development of improved methods of mounting and counting the slides. A.

539.215.08 : 535.827.2

1272. A particle-profile test strip for assessing the accuracy of sizing irregularly shaped particles with a microscope. H. H. Watson and D. F. Mulford. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 105–S 108 (1954).

Describes a particle-profile test strip, which can be used for assessing the errors of sizing irregularly shaped particles with a microscope, using a globe and circle eyepiece graticule. The two hundred irregularly shaped profiles on the test strip were sized under a microscope by nine observers on two occasions. The results obtained and the errors revealed are discussed. It should be possible using the test strip to weed out bad dust-sizing microscopists, and to correct sizing bias of others. A.

539.215.08 : 535.827.2

1273. A microscope method of measuring thicknesses of fine particles. W. H. M. Robins. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 189–S 192 (1954).

The principle of the method is to bring the particle into the space beneath a lens, resting on a plane surface, until the particle is in contact with both lens and plane. The particle's thickness is then calculated from a knowledge of the radius of curvature of the lens and the distance of the particle from the point of contact of lens and plane. The lens, of suitable curvature, forms part of an attachment to the substage condenser mount of a microscope, preferably of the inverted type. A wide range of thicknesses (100 to 3 μ) can be measured. The method has been checked using microscopic spherical particles and the results showed that thicknesses are measured with an accuracy of the order of 10%. A.

539.215.08 : 537.312.5

1274. The automatic size analysis of dust deposits by means of an illuminated slit. L. Le Bouffant and J. L. Soulé. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 143–S 147 (1954).

The analysis of dust deposits by means of an illuminated slit allows simultaneous counting and size distribution analysis. For counting, it is possible to provide statistical compensation of errors due to fractional interception, overlapping, "coincidence," and lack of sensitivity by choice of an optimum slit length. Under these conditions classification by surface area gives accurate size distribution information. An apparatus designed to operate on these principles is described. A.

539.215.08 : 537.312.5

1275. The automatic counting of red blood cells. E. H. Cooke-Yarborough and R. E. Whyard. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 147–S 156 (1954).

Considers apparatus in which the cells are scanned by mechanical oscillation of a microscope stage. It is shown how errors can arise from various sources and how these errors may be minimized by use of suitable electronic circuits, by careful choice of parameters and by adopting a novel shape of scanning

aperture. Counting apparatus whose design follows these principles is described and the results are given of many experiments using this apparatus. These show that consistent results are obtainable which are largely independent of variations in light intensity, focus, cell size, amplifier and photocell sensitivity and of other variations likely to be encountered in practice. A.

539.215.08 : 537.312.5

1276. Stages in the development of an arrested scan type microscopic particle counter. H. A. DELL. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 156–S 161 (1954).

The most detailed analysis of the particles of dust deposited on a plane surface is possible when the surface considered is examined point by point by a spot scanning system. Techniques are described using line-to-line memory systems which provide a single impulse for each particle in each field of scan. These impulses can be used to arrest the normal scanning motion of the spot, which can then explore each particle in turn as it is discovered. The mode of exploration chosen can be designed to exhibit the features of the particles which are of interest. Some simple modes are described. A.

539.215.08 : 537.312.5

1277. Testing a counting machine. R. J. COURSHEE. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 161–S 165 (1954).

The method and results of measuring the accuracy of a particle sizing and counting machine are described and compared with the results obtained when sizing with a microscope. Machine counting appears to be quicker and more consistent and accurate than counting by eye. A.

539.215.08 : 537.312.5

1278. The design and construction of a photoelectronic scanning machine for sizing microscopic particles. P. G. W. HAWKSLEY, J. H. BLACKETT, E. W. MEYER AND A. E. FITZSIMMONS. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 165–S 173 (1954).

The design of photoelectronic scanning machines for counting and sizing particles is discussed. Data are presented on the performance of a machine constructed for sizing particles dispersed on microscope slides. The size distribution of a sample of coal particles down to 5 μ as determined by the scanning machine agrees with that from a visual count. A.

539.215.08 : 537.312.5

1279. An automatic system for obtaining particle size distributions with the aid of the flying spot microscope. W. K. TAYLOR. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 173–S 175 (1954).

A method suitable for particles which have a maximum dimension, in any chosen direction, exceeding a calibrated reference dimension. The method thus enables a histogram of size distribution to be constructed for any convenient grouping, and by rotating the area it is possible to detect whether unsymmetrical particles show a tendency to align themselves in a particular direction. A.

539.215.08 : 537.312.5 : 621.383.27

1280. A photoelectronic instrument for counting and sizing aerosol particles. F. T. GUCKER AND D. G. ROSE. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 138–S 143 (1954).

The instrument, using a new arrangement of stops, collects light scattered between 1 and 20° of the forward direction and focuses it upon a photomultiplier tube. The resulting electrical pulses are amplified, sorted with a single-channel pulse height selector, and counted. With an aerosol of refractive index 1·5, the instrument counts particles of 0·17 μ radius or larger, and its response is linear with radius over the range of 0·25 to 0·50 μ, with a sensitivity of 0·001 μ and a reproducibility of 0·01 μ. Data for a typical 16-step histogram, based upon 3350 counts covering a total range of 0·22 μ, were obtained in 40 min, and could be obtained in 2 min with a 16-channel pulse height selector. A.

539.215.08 : 539.217.1

1281. The application of methods of particle size and surface area measurement to whiting. G. E. BESSEY AND D. C. SOUL. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 181–S 189 (1954).

The application to whiting (calcium carbonate) of various methods of determining particle size distributions and surface area is considered and results by various methods are compared. Techniques for determining sieve residues on fine sieves and particle size distribution by sedimentation are described. These methods, together with surface area measurements by air permeability are considered to give data on whitings adequate for most purposes. A.

539.215.08 : 539.27

1282. The electron microscopy of airborne dusts. J. CARTWRIGHT. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 109–S 120 (1954).

A technique is described for collecting airborne dust samples on membrane-coated cover glasses in a thermal precipitator. Samples thus collected can be counted with either an optical or an electron microscope and only one sample is required for the measurement of the size distribution and concentration of particles in the range from 10 to 0·01 μ. Particles of diameter between 10 and 0·23 μ are counted with an optical microscope and those with diameters between 3·0 and 0·01 μ are counted with an electron microscope. It is shown that any differences between the assessments in the overlap range of the two instruments are due to the greater resolving power of the electron microscope. A.

539.215.08 : 539.6

1283. The adhesion of dust particles. D. W. JORDAN. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 194–S 198 (1954).

An important factor in the handling of dust is the fact that the particles will adhere to each other and to solid surfaces. The mechanism by which this takes place is discussed and some quantitative results are given. It is shown that the intermolecular force between the surfaces in contact is large enough to account for this phenomenon of adhesion, although in some cases electrical forces and other processes may operate giving considerably greater attraction. An

application to dust sampling problems is also mentioned. A.

539.215.08 : 541.18.041.3

1284. The aggregation of aerosols. J. M. Dalla-Valle, C. Orr, Jr and B. L. Hinkle. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 198–S 206 (1954).

Aggregation of the individual particles composing an aerosol is a phenomenon of primary importance in the ageing of the aerosol. The influence of electrification and foreign vapours on the aggregation process has been investigated. Results indicate that electrification amounting to a few electron charges per particle has little effect on the rate of aggregation, but has a decided influence on the shapes of the aggregates. In the case of aerosols whose particles have a significant vapour pressure, certain substances which lower this vapour pressure have been found to increase the rate of aggregation, presumably by reducing the vapour cushion surrounding the particles. When the particles are readily soluble in a substance whose vapour is present, the rate of aggregation also appears to be increased because of reduction of the vapour layer about the particles. A.

539.216 : 535.343.2

The near infra-red absorption spectra of natural and synthetic fibres. *See Abstr.* 843

539.217

1285. The diffusion of helium in sodium chloride. S. J. Thomson and G. Wardle. *Trans Faraday Soc.*, **50**, *Pt* 10, 1051–6 (*Oct.*, 1954).

The diffusion of helium from natural sodium chloride crystals has been studied in air at 25°C and in vacuum between 96°C and 147°C. Diffusion coefficients have been evaluated, based on diffusion from small spheres, and the coefficients may be described in terms of the equation $D = D_0 \exp(-E/RT)$, where $D_0 = 2{\cdot}8 \times 10^{-2}$ cm²sec and $E = 18{\cdot}6 \pm 1{\cdot}4$ kcal/mole. The diffusion is probably volume diffusion as opposed to grain boundary diffusion. A.

539.217

1286. Diffusion of cadmium, indium, and tin in single crystals of silver. C. T. Tomizuka and L. Slifkin. *Phys. Rev.*, **96**, *No.* 3, 610–15 (*Nov.* 1, 1954).

The diffusion coefficient of cadmium, indium, and tin tracers in single crystals of pure silver has been measured as a function of temperature over the range 592–937°C. The activation energies and frequency factors were determined, yielding $D = 0{\cdot}44 \exp(-41\,700/RT)$ for the cadmium tracer, $D = 041 \exp(-40\,630/RT)$ for indium, and $D = 0{\cdot}25 \exp(-39\,300/RT)$ cm²/sec for tin. These values are in marked disagreement with the older data. The results of the present work are discussed in terms of Lazarus' theory and Zener's theory. Both theories give fair agreement with the experimental data. A.

539.217

1287. Concentration contours in grain boundary diffusion. R. T. P. Whipple. *Phil. Mag.*, **45**, 1225–36 (*Dec.*, 1954).

Formulae are obtained for the concentration in a poorly diffusing half space bisected by a thin well-diffusing slab, at different times after the edge of the half-space has been suddenly raised from zero to unit concentration. This represents a simplified model for studying "grain boundary" diffusion of one metal into another. The problem also has obvious application to the study of heat flow in a poorly conducting solid with a metallic fin. A.

539.217

1288. Self-diffusion in copper. A. Kuper, H. Letaw, Jr, L. Slifkin, E. Sonder and C. T. Tomizuka. *Phys. Rev.*, **96**, *No.* 5, 1224–5 (*Dec.* 1, 1954).

The self-diffusion coefficient of copper has been determined by tracer techniques through the use of a precision grinder and a precision lathe. The temperature dependence over the range 685–1062°C is given by $D = 0{\cdot}468 \exp(-47\,140/RT)$ cm²/sec. A.

539.217 : 539.67

Diffusion of B in Fe. *See Abstr.* 1306

539.217.1 : 533.15

1289. The measurement of surface area of finely divided solids by the flow of gases through them. R. M. Barrer. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 41–S 49 (1954).

An account is given of the theory and application of several procedures which have been used for determining the surface areas of finely divided solids, and which depend upon either the steady or the transient state of flow. Characteristic differences can arise between pore properties of microporous media determined by steady and by transient state methods which have at least in part received an explanation in terms of the heterogeneity of pore sizes and in the presence of some blind pores. Attention has been directed to several additional possible procedures for measuring surface areas. These refer to flow systems in which a saturated immobile monolayer is formed at all points reached by the flowing gas. One of the latter methods covers the case where a mobile, dilute second layer forms on the immobile saturated first layer and where transport of sorbate may occur by combinations of one or more of Poiseuille, Knudsen and surface flow. A.

539.217.1 : 533.15

1290. An examination of the behaviour of adsorbed molecules by the flow of gases through microporous media. R. M. Barrer. *Brit. J. appl. Phys., Suppl. No.* 3 [*Physics of particle size analysis*] S 49–S 55 (1954).

Considerable information can be obtained by flow methods concerning the properties of gases adsorbed in microporous media. Of particular interest is the measurement of surface migration and of surface diffusion coefficients, D_s; this may be measured by a steady state method in more concentrated films. It may also be found by the transient state time-lag procedure in adsorbed films dilute enough to obey Henry's law. The ratios of the energies, E, required to render adsorbed molecules mobile to the heats of desorption (ΔH) from the surface are from 0·5 to 0·6 for simple molecules in porous glass up to 0·8 to 0·9 for complex molecules like *n*-heptane, or toluene on silica gel or carbon. The surface diffusion coefficients, D_s, depend upon the concentration in the adsorbed films. If $D_s = D_0^s(1 + f(C_s'))$ denotes the relation between D_s and surface concentration C_s' in mole-

cules per cm², then a general relationship exists between $f(C_s')$ and the curvature of the adsorption isotherm. This may permit the value of D_s and its concentration dependence to be measured over the range of C_s' within which surface migration may be described by the generalized Fick law

$$\frac{\partial C_s'}{\partial t} = \frac{\partial}{\partial x}\left(D_s \frac{\partial C_s'}{\partial x}\right)$$

while molecular streaming occurs in the gas phase. A.

539.217.1 : 533.15

1291. The flow of gases through packed beds of colloidal carbon blacks. H. W. Davidson and B. M. Turk. *Brit. J. appl. Phys. Suppl. No.* 3 [*Physics of particle size analysis*] S 55–S 60 (1954).

The flow of hydrogen, nitrogen and argon through packed beds of lamp- and carbon-blacks has been studied at atmospheric pressure and very low gas velocities. These materials can be packed to cover an appreciable range of porosities and so permit examination of the relationship between porosity and permeability over a wide range. It is found that: (*a*) the porosity functions suggested by Kozeny, Carman and Arnell are not applicable to such beds; (*b*) the permeability of the bed is related to the fourth power of the bed density; (*c*) in the case of undensed blacks the permeability is related to the particle size; while for densed blacks the flow is governed by the width of channels between aggregates. There is reason to hope that this investigation provides the basis of a method for the estimation of the surface area of colloidal carbons. A.

539.23

1292. On the near contact layer in copper oxide. A. I. Andrievskiĭ and M. T. Mishchenko. *Zh. tekh. Fiz.*, **24,** *No.* 5, 818–25 (1954) In Russian.

A study by optical microscopy of this layer in terms of changes in the metallic structure at high (1000°c) temperatures. Seventeen plates.

W. BARDSLEY

539.234

1293. Exchange of atoms in condensation of a molecular jet. M. Devienne. *C.R. Acad. Sci.* [*Paris*] **239,** *No.* 19, 1202–3 (*Nov.* 8, 1954) In French.

A thin film of Sb containing some radioactive tracer molecules is condensed on a surface; this film is later exposed to a jet of non-radioactive Sb from an apparatus as described in Abstr. 3022 (1952). It is found that the sides of the container become radioactive, suggesting that the jet has released some of the material present in the original film. Considerable experimental precautions are taken to avoid heating this film, but further experiments are in progress to determine whether these precautions are sufficient.

N. CORCORAN

539.27

1294. The utilization of the depth of focus of the electron microscope for photographs of low magnification. F. Leonhard. *Optik*, **11,** *No.* 9, 407–11 (1954) In German.

Frequently in metallographic work, the depth of focus (1 micron) of the optical microscope is insufficient. In such cases, it pays to use an electron microscope at the same magnification but with a depth of focus of some 200 microns. Careful replica technique is required to obtain replicas with a suitably large field of view. A. E. I. RESEARCH LABORATORY

539.27

1295. Experimental studies of the contrast in the electron microscope. W. Lippert. *Optik*, **11,** *No.* 9, 412–21 (1954) In German.

Several theoretical investigations have been made into the mechanism of contrast in the electron microscope. This paper describes experimental work carried out firstly to establish a reproducible experimental technique for scattering measurements, and secondly to compare actual scattering cross-sections with those calculated. Aluminium oxide foils were used as the specimens and curves are given showing the variation of scattering cross-section with electron accelerating voltage and objective aperture. An electromagnetic electron microscope was employed.

A. E. I. RESEARCH LABORATORY

539.27

1296. The transparency of the supporting films to the electron beam in the electron microscope. K. Weber and C. v. Fragstein. *Optik*, **11,** *No.* 11, 511–23 (1954) In German.

The relation is measured between the film thickness of usable films of material and their transparency to electrons. The thickness of the thin films used is determined by multiple-beam interferometry and the transmission to electrons in the normal beam in an electron microscope is measured directly with a Faraday cylinder and galvanometer. Measurements are reported for lacquer, Mowital, Formvar and silicon monoxide films. The structures of the films used are described and the technique of making the films is discussed. Results are presented in the form of curves; the thickness covers the ranges 0–150 mμ.

S. TOLANSKY

539.27

1297. A study of the shape, surface structure and frictional wear of fibres by reflexion electron microscopy. J. A. Chapman and J. W. Menter. *Proc. Roy. Soc. A*, **226,** 400–7 (*Nov.* 23, 1954).

The reflection electron microscope has been used in a direct study of the shape and surface structure of small fibres of orlon, viscose rayon, cellulose acetate, glass wool, and undrawn and drawn nylon. The images obtained are superior in resolution and depth of field to those obtained by conventional optical methods and have the particular advantage of presenting a focused image of a large part of the curved surface. It is thus possible to evaluate the shape and surface structure of a fibre much more readily than with the optical microscope. The friction and wear of single fibres of drawn nylon when a flat platinum slider is rubbed once along the fibre has been investigated, using the reflection technique. It has been found that under high sliding pressures the fibre undergoes considerable permanent deformation and severe tearing occurs at the centre of the track. A.

539.27 : 548.74

1298. An electron diffraction specimen chamber with a specimen vacuum lock. R. B. Kehoe, R. C. Newman and D. W. Pashley. *J. sci. Instrum.*, **31,** *No.* 11, 399–400 (*Nov.*, 1954).

The specimen chamber of a new electron diffraction

camera is described. A novel feature is the inclusion of a cover which allows the vacuum to be maintained immediately around the specimen, when air is admitted to the camera. This allows various operations to be carried out on the camera, without the specimen being exposed to the atmosphere. In addition, it is possible for specimens, while enclosed by the vacuum cover, to be transferred to the camera from external apparatus. Successful applications of this vacuum lock are given. A.

ELASTICITY . STRENGTH . RHEOLOGY
539.3/.8

539.371 : 536.7

1299. Thermodynamical theory of deformations in highly-elastic materials. G. M. Bartenev. *Zh. éksper. teor. Fiz.*, **25**, *No.* 2 (8) 225–34 (1953) In Russian.

An attempt at developing a consistent thermodynamical theory of highly-elastic deformations of rubber and exact thermodynamical relationships for determining the entropy and energy components of elastic force in different highly-elastic substances. It is found that, in the absence of crystallization, the elasticity of rubber at small and medium deformations is of the pure entropy (ideal) nature.

F. LACHMAN

539.373 : 548.0

1300. The slip modes of titanium and the effect of purity on their occurrence during tensile deformation of single crystals. A. T. Churchman. *Proc. Roy. Soc. A*, **226**, 216–26 (*Nov.* 9, 1954).

Single-crystal test specimens of van Arkel titanium were obtained by a modification of the strain anneal technique. The modes of slip have been identified as $(10\bar{1}0)$ $[11\bar{2}0]$, $(10\bar{1}1)$ $[11\bar{2}0]$, and (0001) $[11\bar{2}0]$. It has been shown that not only does the interstitial impurity affect the magnitude of the critical resolved shear stress but also the relative values for the three slip systems. $(10\bar{1}0)$ is the principal slip system and is favoured by increasing purity. A possible mechanism for the role of oxygen and nitrogen in this effect is put forward, wherein it is shown that the interstitial sites occupied are such that interstitial elements render slip more difficult on two of the three slip planes in titanium. A.

539.374 : 539.501

1301. Mathematical structure of the theories of viscoelasticity. B. Gross. *Paris: Hermann et Cie* (1953), 74 *pp.* [*Actualités Scientifiques et Industrielles*].

The first of a series of monographs on "Rheology" from the Brazilian National Institute of Technology, comprising a systematic discussion of the relations between stress and strain that represent the most general type of viscoelastic behaviour consistent with the principle of superposition. A complete duality between stress and strain is emphasized throughout. The distribution function of relaxation times, the relaxation function, and the complex modulus function for periodic strains are related with the distribution function of retardation times, the creep function, and the complex compliance function. Exact formulae suitable for numerical calculations are derived. Bibliography.

J. G. OLDROYD

539.389.3

1302. Elastic after-effect in α-iron in relation to the elastic constants of cubic metals. J. Smit and H. G. van Bueren. *Philips Res. Rep.*, **9**, *No.* 6, 460–8 (*Dec.*, 1954).

The elastic after-effect in α-iron, containing carbon or nitrogen in solid solution, can be interpreted as causing a change of the elastic moduli of the material. This interpretation renders it possible to estimate with a reasonable degree of accuracy the magnitude of the after-effect in polycrystalline materials. The estimate is based on a general relation which is shown to exist between the elastic constants of single crystals and of polycrystalline specimens of the cubic metals. A.

539.434

1303. Mechanisms of creep in a precipitation hardened alloy. G. C. E. Olds. *Proc. Phys. Soc.* [*London*] *B*, **67**, *Pt* 11, 832–42 (*Nov.*, 1954).

The binary alloy 97% copper–3% silver was selected as the most ideal alloy for research on the creep process in a precipitation hardened alloy. A heat treatment was devised which gave a slightly overaged Widmanstätten structure of high internal hardness and maximum stability. Wires of the alloy were subjected to deformation over a range of constant stresses at temperatures from 100°C to 300°C. Two mechanisms of transient creep were observed and were found to be complementary. The first mechanism occurred at the lower temperatures giving creep strain proportional to ln (time), whilst the second mechanism in which creep was proportional to $(\text{time})^{1/3}$ appeared and became dominant at higher temperatures. A quasi-viscous creep mechanism was also observed which at high temperatures was more important than the transient process. The linear nature of the quasi-viscous creep was limited by a critical time, and was believed to be governed by the plastic deformation which occurred on loading. The three mechanisms observed agree with some theoretical analyses which have been put forward. A.

539.62

1304. Mechanoelectronic transducer system for recording friction with a "stick-slip" machine. R. C. Bowers and W. C. Clinton. Letter in *Rev. sci. Instrum.*, **25**, *No.* 10, 1037–8 (*Oct.*, 1954).

New method described for recording frictional force in Bowden–Leben friction machine. Displacement of bifilar suspension causes current variation in RCA 5734 vacuum tube mechanoelectronic transducer, forming one arm of bridge circuit. Out-of-balance potential across bridge displayed on cathode ray oscilloscope gives direct measure of frictional force.

J. W. MENTER

539.67

1305. Internal friction in glass. II. Flexural and torsional vibrations. P. L. Kirby. *J. Soc. Glass Technol.*, **38**, 383–420 (*Aug.*, 1954).

For Pt I, see Abstr. 3003 (1953). The basic methods which have been used to study internal friction or specific damping capacity are reviewed. Apparatus

for studying the internal friction of thin rods of fused silica, a soda–lime–silica and a borosilicate glass undergoing transverse vibration (0·3—50 c/s) and torsional vibration (1—50 c/s) is described. The peculiar difficulties in obtaining an absolute measure of the internal friction in the case of transverse vibration at low frequencies are discussed. It is shown that there are two physical processes which contribute to the internal friction at these frequencies, a relaxation of alkali ions in the glass and the visco-elastic behaviour of the remainder of the vitreous network. This hypothesis is supported by a clear dependence of the internal friction on the thermal history of the specimen. At constant temperature the internal friction decreases with increasing frequency, but there is no evidence of a maximum value at low frequencies. The variation of internal friction with temperature shows a frequency-dependent peak value, indicating a process with an activation energy similar to that governing the movement of alkali ions in the glass. At higher temperatures the dependence of the internal friction on frequency and thermal history is illustrated, and note is made of the use of the results in an estimation of the distribution of relaxation periods among visco-elastic elements in the network. Incidental results are appended giving the variation of elastic moduli with temperature, and the possibility of thermo-elastic coupling in glass is discussed. A.

539.67 : 539.217

1306. Internal friction of alpha-iron due to boron atoms. R. R. HASIGUTI AND G. KAMOSHITA. Note in *J. Phys. Soc. Japan*, **9**, *No.* 4, 646–7 (*July–Aug.*, 1954).

It is concluded that B dissolves interstitially in αFe because even when present in very low concentration ($\sim 10^{-5}$ at %) it produces an internal friction peak, similar in height to those produced by C and by N when these are present in comparable amounts. From the position at which the peak occurs for the frequency used the diffusion coefficient of B in Fe is calculated to be $2{\cdot}9 \times 10^{-12}$ cm²/sec at 128°C.

A. D. LE CLAIRE

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM. CHEMICAL REACTIONS 541.11/.12

541.123.2 : 523.47/.48

1307. Metallic ammonium. M. J. M. BERNAL AND H. S. W. MASSEY. *Monthly Not. Roy. Astron. Soc.*, **114**, *No.* 2, 172–9 (1954).

It has been pointed out by Ramsey that metallic ammonium (NH_4) may be important in determining the properties of Uranus and Neptune. The pressure–density relation for this metal at pressures of importance in this connection is calculated by quantal methods. The transition pressure for the phase transition from mixed crystals of ammonia and hydrogen (NH_3 and $\frac{1}{2}H_2$) to ammonium metal is also investigated and found to be almost certainly less than 250 000 atmospheres, so that the metallic phase will persist throughout the bulk of the two planets mentioned. A.

541.124

1308. Mechanism of formation of the quinonoid hydrocarbon $CH_2 : C_6H_4 : CH_2$. M. LEVY, M. SZWARC AND J. THROSSELL. *J. chem. Phys.*, **22**, *No.* 11, 1904–11 (*Nov.*, 1954).

541.126

1309. Instability of tangential detonations in a compressible medium. S. I. SŸROVATSKIĬ. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 1, 121–3 (1954) In Russian.

It is shown that tangential detonations are unstable even with respect to infinitely small perturbations, and that there is no critical velocity jump at the detonation front above which they become stable, as incorrectly stated by L. D. Landau [*Dokl. Akad. Nauk SSSR*, **44**, 151 (1944)]. A. GELBTUCH

541.126

1310. The physics and chemistry of a self-sustained reaction between iron and potassium permanganate. R. A. W. HILL. *Proc. Roy. Soc. A*, **226**, 455–71 (*Dec.* 7, 1954).

Self-sustained reaction between reduced iron powder and finely powdered potassium permanganate in the proportions 80/20 by weight has been investigated by recording temperature changes as the reaction front passes a point. Velocities of propagation calculated from these records by means of the thermal theory agree well with directly observed velocities. It is therefore considered that this theory is a good representation of the behaviour of this composition, and that it may be used to calculate reaction rates from temperature records. Reaction rates so obtained have been expressed as functions of the absolute temperature and the extent of reaction. It is found that the kinetics at low density (loose powder) are very different from those at high density (hard pellets); and that the difference can be explained on the hypothesis that at low density the reaction takes place by way of the gas phase, and at high density, where contact is better, by diffusion across solid-solid interfaces. It is thought that the mobile species at low density is O_2, at high density Fe^{2+}. Support for this view is obtained by measuring the cooling curves of the products and by calculating the atomic heats of the products from observed final temperatures and heats of reaction. Thermal and X-ray data are used in an attempt to formulate the chemical change. In the experimental section, methods of measuring temperatures, thermal conductivities (three methods) and heats of reaction are described. A.

541.127

1311. A general asymptotic solution of reaction equations common in solid-state chemistry. G. BROUWER. *Philips Res. Rep.*, **9**, *No.* 5, 366–76 (*Oct.*, 1954).

A theory of the chemistry of semiconductors, given recently by Kröger, Vink and Van den Boomgaard, is based on a number of reaction equations and certain

additional conditions, including electroneutrality. A simple way to find an analytical or graphical approximate solution of this set of equations is presented in this report. Two examples are given; the method, however, is not restricted to these systems. The accuracy of the method is quite sufficient to serve its purpose. A.

541.128

1312. Catalysis on evaporated metal films. V. Reactions between cyclic hydrocarbons and deuterium. J. R. Anderson and C. Kemball. *Proc. Roy. Soc. A*, **226**, 472–89 (*Dec.* 7, 1954).

For Pt IV, see Abstr. 6960 (1954). Catalytic exchange reactions have been studied by means of a mass spectrometer between deuterium and *cyclo*pentane over palladium and *cyclo*hexane over rhodium, palladium, tungsten, platinum, nickel, oriented nickel and oriented rhodium. Activation energies, frequency factors and distributions of initial products were determined. The reactions involved multiple exchange by repeated second-point adsorption. Half the hydrogen atoms were readily exchanged, and a study of the temperature-dependence of the product distributions showed that it required an activation energy of 4 to 8 kcal/mole in excess of that for adsorption-desorption before the remaining half could be exchanged. Considerations of molecular geometry revealed that in order to exchange the second half of the hydrogen atoms the molecule had to "turn over" on the surface, and for *cyclo*pentane the process for turning over must require second-point adsorption by the same carbon atom, but with *cyclo*hexane there is the alternative process of exchanging two adjacent equatorial hydrogen atoms. Theories are developed which account satisfactorily for the observed initial product distributions. The pressure-dependence of reaction rate was determined for *cyclo*hexane over palladium. Deuterium was strongly adsorbed and *cyclo*hexane weakly adsorbed. Exchange of *cyclo*hexane over oriented films of nickel and rhodium showed marked differences in distribution compared with unoriented films, suggesting different catalytic activity of different crystal planes. Only exchange was observed with benzene over nickel, but there was simultaneous exchange and deuteration over palladium. The initial product pattern over palladium showed that a redistribution reaction in the sense of Wagner *et al.* [Abstr. 3960 (1952)], did not occur during deuteration and that benzene was adsorbed mainly as phenyl radicals during the exchange reaction. The reaction between *cyclo*propane and deuterium was examined over rhodium and simultaneous exchange and deuteration were observed. As determined by the temperature range for reaction the order of reactivity in exchange was *cyclo*propane > *cyclo*pentane > *cyclo*hexane, and the order of catalytic activity of the metals was similar to that observed previously for the exchange of other saturated hycrocarbons. A.

ELECTROCHEMISTRY 541.13

541.13

1313. The fundamentals of electrochemistry. T. G. Owe Berg. *Appl. sci. Res. A*, **5**, *No.* 1, 31–44 (1954).

The concept of free ions in a solution is contradictory to present knowledge of molecular bonds and liquid structure. If this concept is discarded, electrochemistry may be based on the same foundation as electrophysics. A.

541.133 : 530.162

1314. The statistical mechanics of electrical conduction in fluids. M. S. Green. *J. phys. Chem.*, **58**, *No.* 9, 714–16 (*Sept.*, 1954).

A method has been developed to discuss irreversible processes in fluids from a statistical mechanical point of view. The flows of macroscopically observable quantities are shown to be linear functions of corresponding thermodynamic forces with coefficients given explicitly in terms of certain random processes. The theory is applied specifically to a model of an electrolyte in which certain molecular species carry electrical charges and in which external fields are possibly present. Expressions for conductivities and other irreversible coefficients in terms of specific random processes are given. The thermodynamic forces are discussed. A.

541.133 : 541.64

1315. Conductance of polyelectrolytes under pressure. F. T. Wall and S. J. Gill. *J. phys. Chem.*, **58**, *No.* 9, 740–6 (*Sept.*, 1954).

The conductivities of dilute aqueous solutions of potassium chloride, hydrochloric acid, acetic acid, polyacrylic acid, styrene-maleic acid copolymer, polyvinyl potassium sulphate and a series of sodium phosphates were measured at 25° and pressures up to 1000 bars. The degree of dissociation of polyacrylic acid was observed to be a linear function of pressure with the pressure coefficient a function of the concentration. The results are treated thermodynamically to obtain volume changes attending the process of ionization. The volume change associated with the ionization of polyacrylic acid at zero degree of ionization is $-17{\cdot}7$ cm^3 per mole of carboxyl groups, but with increasing degree of dissociation the volume change becomes less negative. The data are interpreted theoretically on the basis of a simple spherical model for the polyion. The sodium phosphates studied show an increasing pressure coefficient of conductance with increasing chain length. A.

541.133.08

1316. A new cell design for precision conductimetry. J. C. Nichol and R. M. Fuoss. *J. phys. Chem.*, **58**, *No.* 9, 696–9 (*Sept.*, 1954).

The design of a conductance cell intended for use with dilute non-aqueous solutions is described. The electrodes (bright platinum) are concentric cylinders with the lead to the outer electrode being a platinum tube which acts as an electrical shield for the lead to the inner electrode. Stray electrical paths are thus eliminated. The electrode assembly is mounted on a Teflon plug which is turned to a standard taper, so that the electrodes are interchangeable. Tests covering the resistance range $1000 \leqslant R \leqslant 50\,000$ ohms over the frequency range $500 \leqslant f \leqslant 5000$ c/s show that the frequency variation is significantly less than that obtained with cells of other designs. Resistances up to 50 000 ohms can be measured with a precision of at least $0{\cdot}02\%$. The R–$f^{-\frac{1}{2}}$ plot is nearly linear at low resistances but its curvature steadily increases with cell resistance; the curve can be accurately reproduced

by a parabola. Consequently, a simple numerical extrapolation to infinite frequency can be made, using data at three frequencies equally spaced on a $f^{-\frac{1}{2}}$ scale (e.g. 5000, 1250 and 556 c/s). A.

541.134

1317. Electrochemical behaviour of cation exchange membranes in liquid ammonia. M. J. BERGIN AND A. H. A. HEYN. *J. Amer. Chem. Soc.*, **76**, *No.* 19, 4765–9 (*Oct.* 5, 1954).

Cationic ion-exchange membrane electrodes are used successfully in liquid ammonia, alcohol and water solutions to measure junction potentials. These measurements may be then utilized in standard electrochemical equations to calculate cationic concentrations. In addition such membrane electrodes are shown to be valuable as a means of determining the ratios of activity coefficients of salts in the above-mentioned media. A.

541.134 : 536.7

1318. Thermopotentials in thermocells. P. MAZUR. *J. phys. Chem.*, **58**, *No.* 9, 700–2 (*Sept.*, 1954).

The thermodynamics of irreversible processes is applied to thermocells. The results of the theory are discussed in connection with the experimental data. Some general relations between thermopotentials of thermocells and the temperature coefficient for isothermal cells are given. A.

541.135

1319. Electrolytes: from dilute solutions to fused salts. C. A. KRAUS. *J. phys. Chem.*, **58**, *No.* 9, 673–83 (*Sept.*, 1954).

The properties, particularly the conductance of electrolyte solutions in different solvents, including water, are critically reviewed in the light of current theories. These theories account rather successfully for the properties of electrolytic solutions in all solvents. Concentrated solutions are best looked upon as solutions of solvent in fused salt. The concentrations at which the theories of dilute solutions begin to fail in a significant manner remain uncertain. A.

541.135

1320. Relative chemical potentials of electrolytes and the application of their gradients. H. S. HARNED. *J. phys. Chem.*, **58**, *No.* 9, 683–6 (*Sept.*, 1954).

Following some general remarks on the present state of knowledge of the relative chemical potentials of electrolytes, some recent determinations of activity coefficients of systems containing two electrolytes in concentrated solutions are discussed. The theory of irreversible processes emphasizes the role of the gradient of the chemical potential as a "force" in causing the motions of the components of the solutions. Recent results on the diffusion coefficients of electrolytes in aqueous solutions are employed to assess the importance of this role. A.

541.135

1321. The true ionization constant of carbonic acid in aqueous solution from 5 to 45°. K. F. WISSBRUN, D. M. FRENCH AND A. PATTERSON, JR. *J. phys. Chem.*, **58**, *No.* 9, 693–5 (*Sept.*, 1954).

This has been determined at 5, 15, 25, 35, 38 and 45° through calculations utilizing the results of high field conductance measurements at the same temperatures. The true ionization constants, in contrast with the apparent ionization constants, change but little with change in temperature. A.

541.135 : 536.7

1322. The thermodynamics of electrolytes at higher concentration. M. EIGEN AND E. WICKE. *J. phys. Chem.*, **58**, *No.* 9, 702–14 (*Sept.*, 1954).

The thermodynamic behaviour of electrolytes in aqueous solutions up to high concentrations is described on a uniform theoretical basis. In addition to the electrostatic interaction of the ions two properties of the electrolyte prove to be especially characteristic of the thermodynamic behaviour: 1st, the space requirement of hydrated ions in the ionic atmosphere; 2nd, an incomplete dissociation appearing for a large number of electrolytes at higher concentrations. The quantity characteristic for the space requirement of the hydrated ions and for the formation of undissociated molecules is the hydration radius "*a*," which is approximately known from values of the apparent molar functions at infinite dilution. By introduction of new distribution formulae for the ionic atmosphere in the theory of Debye and Hückel, which follow from statistical and thermodynamical considerations analogous to adsorption statistics or to Eucken's treatment of hydration shells, the properties of some completely dissociated electrolytes such as Li halides, $MgCl_2$ and others, are calculated and found to be in good agreement with experimental data. Other applications of the distribution formula—especially with respect to colloid ions—are indicated. In the general case one has to consider the additional effect of incomplete dissociation. Then the calculations of mean activity coefficients, heats of dilution and apparent molar heat capacities from the expression for the free energy are in fair agreement with experimental data for 1–1, 2–2, 1–2 and 1–3 electrolytes up to concentrations of about 1 to 4 molar. The effect of incomplete dissociation appears most obviously, separated from other effects, in sound absorption results of some electrolytic solutions. In addition, the relaxation effects of the hydration shells of the ionic atmosphere, and of the dissociation equilibrium are discussed with respect to heat conductivity, electrical conductivity and sound absorption data of electrolytic solutions. The last-mentioned quantity gives information about the kinetics of extremely fast ionic reactions in aqueous solutions. A.

541.135 : 536.7

1323. Thermodynamic properties of mixtures of electrolytes in aqueous solutions. T. F. YOUNG AND M. B. SMITH. *J. phys. Chem.*, **58**, *No.* 9, 716–24 (*Sept.*, 1954).

The mean apparent molal volume of two electrolytes in an aqueous solution may be calculated from known values of the apparent molal volume of each electrolyte in the binary solution whose ionic strength is that of the ternary solution. The relatively small discrepancies between the values so calculated and experimental data can be represented by simple algebraic expressions, i.e. "interaction terms." Combination of the interaction terms with the basic equation leads to equations which may be differentiated to yield explicit expressions for partial molal

volumes. The calculations agree well with "experimental" determinations of partial molal volumes. The forms of the curves representing the changes in enthalpy occurring when two solutions of the same ionic strength are mixed are comparable with the corresponding volume curves. Some general relations have been observed between the constants of equations for the enthalpies of binary solutions of electrolytes of the 1–1, 1–2, 2–1 charge types. These relationships when extended by further experiments promise to make it possible to base predictions of enthalpies of solutions upon the constitutions of the electrolytes involved. A.

541.135 : 541.64

1324. A chain model for polyelectrolytes. I. F. E. Harris and S. A. Rice. *J. phys. Chem.*, **58**, *No.* 9, 725–32 (*Sept.*, 1954).

The various theories of polyelectrolyte behaviour are examined and the nature of the approximations inherent in each are discussed. A new model of the polyion in solution is proposed and an outline is described for the evaluation of the free energy of the polyelectrolyte solution, including the effects of dissociation, binding and entropy of distribution of the unionized groups, ions and bound ion pairs. The binding of counter ions by the polymer is related to the pH, and comparison with experimental data of the theoretical relationship gives indications as to the nature of the binding process. The entropy of distribution among charged and uncharged sites on the polymer chain is evaluated, considering interaction between nearest neighbouring sites, and is found to decrease markedly from its value for a random distribution, especially at intermediate degrees of neutralization. This large decrease in entropy as the degree of neutralization increases is responsible for the extensive binding of counter ions which is experimentally observed. These manifestations of non-ideal behaviour make it impossible to use the previously accepted relationship between the pH of the solution and the thermodynamic properties of the polyion. A.

541.135 : 541.64

1325. A chain model for polyelectrolytes. II. S. A. Rice and F. E. Harris. *J. phys. Chem.*, **58**, *No.* 9, 733–9 (*Sept.*, 1954).

The chain model for polyelectrolytes proposed in Pt I is further developed by considering in more detail the electrostatic interaction energy between the charges of the polymer. It is pointed out that not all of the electrostatic energy is effective in expanding the polymer and that the weighting of the probability of the configurations must depend upon factors other than their end-to-end distances. Expansions are calculated assuming that only nearest neighbouring links of the polymer chain interact to alter the distribution of lengths. Calculated and experimental expansions are compared for carboxymethylcellulose and polymethacrylic acid. The results for CMC are in good agreement with the theory while those for PMA deviate in the direction expected if significant higher order interactions were omitted. The degree of binding of counter ions is also calculated and compared with experimental values for polyacrylic acid. It is found that the calculated degree of binding is not very sensitive to the approximations used and semi-quantitative agreement with experiment is obtained. The discrepancy is of the right sign and magnitude to be interpreted in terms of further interactions whose effect was neglected in the present calculations. A.

541.135.2

1326. Electronic configuration in electrodeposition from aqueous solutions. I. The effect of ionic structures. E. H. Lyons, Jr. *J. Electrochem. Soc.*, **101**, *No.* 7, 363–75 (*July*, 1954).

Consideration of electronic structures of metal ions in aqueous solutions indicates that metals are electrodeposited from ions in which co-ordinate linkages involve only orbitals of the outermost electronic shell. When co-ordination involves the penultimate shell also, that is, with Taube's "inner orbital" complexes, the metal is not electrodeposited. Apparently the energy required to break such hybridization exceeds that required for cathodic discharge of hydrogen from these solutions. Platinum metals are exceptions, probably because of extraordinary stability of the metallic state for these elements; deposition, however, requires high activation, as shown by overpotentials and low current efficiencies. Between different oxidation states, electrolytic oxidation or reduction is irreversible if the electronic configuration must be changed significantly. Irreversible deposition is observed for transition metals or when the ion is bound in a hydrolysed aggregate. Since inner orbital hybridization is associated with a lack of substitutional lability of the co-ordinated groups, whereas lability of outer orbital complexes probably results from formation of a dissociation intermediate, it is likely that such an intermediate is also important in the cathode process. These considerations are used to account for and extend the Piontelli electrolytic classification of metals. In considering the effects of anions, it is shown that aquo complexes are reduced with highest irreversibility, which is attributed to high activity of water; the influence of halide ions may be labilization by the trans effect. A.

541.135.2

1327. Electronic configuration in electrodeposition from aqueous solutions. II. The deposition process. E. H. Lyons, Jr. *J. Electrochem. Soc.*, **101**, *No.* 7, 376–81 (*July*, 1954).

It is proposed that electrodeposition proceeds through an intermediate complex ion adsorbed on the cathode by a co-ordinated bridge. Subsequently, the bridge is eliminated and a metallic bond established. By applying Pauling's theory of the metallic state, reversible deposition of post-transition metals and irreversible deposition of transition metals are explained. A close correlation with electron-transfer reactions is shown. Inclusions in deposits represent residual co-ordinated groups, in agreement with results of recent studies. A.

541.135.2

1328. Electronic configuration in electrodeposition from aqueous solution. III. Metal deposition from certain complex ions. E. H. Lyons, Jr, J. C. Bailar, Jr and H. A. Laitinen. *J. Electrochem. Soc.*, **101**, *No.* 8, 410–14 (*Aug.*, 1954).

The cathodic behaviour of cobalt, nickel, copper and zinc complexes of 8-hydroxy-quinoline-5-sul-

phonic acid, 1, 10-phenanthroline, glycine, 1, 2- and 1, 8-naphthalenediamines, tetramethylethylenediamine and dimethylglyoxime was investigated by determining cathode current efficiencies and polarograms. Deposition was not obtained from ions believed to have hybridized orbitals which involve the penultimate electron shell, that is, from the "inner orbital" complexes of Taube. Deposits were obtained from "outer orbital" ions, thus confirming the rule previously proposed. Evidence is given that copper, as well as cobalt and nickel, forms both types of ions. A.

541.135.5

1329. Theory of the differential capacitance of the double layer in unadsorbed electrolytes. J. R. MACDONALD. *J. chem. Phys.*, **22**, *No.* 11, 1857–66 (*Nov.*, 1954).

A partly phenomenological one-dimensional theory is presented of the double layer formed at an ideal polarized electrode in uni-univalent aqueous electrolytes showing no specific adsorption. The system analysed consists of the metallic electrode with its surface charge density, a charge-free layer next to the electrode, and a diffuse layer containing positive and negative charges in unequal concentration extending into the body of the electrolyte. The theory includes the effect of dielectric saturation in both layers due to the field produced by an applied negative bias potential, and compression of the charge-free layer by this field is also taken into account. The theory is compared with experimental data of Grahame on 0·916N to 0·001N NaF, which shows little or no adsorption on negative polarization. Good agreement is found both for the dependence of the differential capacitance of the entire system on negative polarizing potential (measured from the electrocapillary maximum) and on concentration. Such agreement allows several constants of the charge-free layer to be obtained relatively accurately. In particular, values for its initial thickness, modulus of linear compressibility, initial dielectric constant and dielectric saturation constant are obtained. Comparison of these results with corresponding results for bulk water affords strong evidence that the charge-free layer consists of a single molecule of water and thus that cations nearest the polarized electrode are hydrated. A.

PHOTOCHEMISTRY . RADIATION CHEMISTRY 541.14/.15

541.14

1330. Photochemical reactions in the system methyl iodide–iodine–methane; the reaction $C^{14}H_3 + CH_4 \rightarrow C^{14}H_4 + CH_3$. G. M. HARRIS AND J. E. WILLARD. *J. Amer. Chem. Soc.*, **76**, *No.* 18, 4678–86 (*Sept.* 20, 1954).

The purpose of this research was to investigate the feasibility of using the photodissociation of $C^{14}H_3I$ as a means of producing labelled methyl radicals for use in studying their reactions. A.

541.14

1331. An investigation of the low pressure photolysis of acetone by means of the mass spectrometer. T. RUBIN AND R. O. LEACH. *J. Amer. Chem. Soc.*, **76**, *No.* 18, 4674–8 (*Sept.* 20, 1954).

The photolysis of acetone in the wavelength region 2800 to 3100 Å has been studied by means of mass spectrometric technique. The pressure includes those in the range from 5 to 100 μ. Additional steps in the mechanism proposed by Dorfman and Noyes and Herr and Noyes appear to be demanded by the data. A.

541.14

1332. Photolysis of methyl bromide in the presence of mercury. C. F. BOYNTON, JR AND H. A. TAYLOR. *J. chem. Phys.*, **22**, *No.* 11, 1929–33 (*Nov.*, 1954).

A study has been made of the photolysis of methyl bromide in the presence of liquid mercury over a pressure range of the bromide from 25 to 100 mm and at temperatures from 35° to 200°c. The removal of the bromine atoms formed in the initial split as mercurous bromide reduces the back reaction. Unlike the corresponding reaction with silver, ethane is formed in considerable amounts. The rate of methane formation decreases while that of ethane formation increases with duration of photolysis. The rate of methane formation increases and that of ethane decreases with increase in pressure of methyl bromide. The energy of activation of methane production in the absence of mercury is 2·1 kcal. In the presence of mercury the energy of activation for methane is approximately zero while that for ethane is less than 2 kcal. The results are interpreted as indicating the formation of mercury methyl radicals or mercury dimethyl. A.

541.15

1333. The radiation chemistry of the aliphatic alcohols. W. R. MCDONELL AND A. S. NEWTON. *J. Amer. Chem. Soc.*, **76**, *No.* 18, 4651–8 (*Sept.* 20, 1954).

The products formed in the irradiation of the liquid, air-free alcohols, methyl, ethyl, *n*-propyl, isopropyl, *n*-butyl, isobutyl, *s*-butyl, *t*-butyl, *n*-octyl and *n*-decyl, with 28 MeV helium ions have been determined. The reduced products were hydrogen and saturated hydrocarbons with a total $G_{(\text{reduction})}$ of 7 to 8 equivalents per 100 eV in all cases. The oxidized products were aldehydes and glycols from primary alcohols, aldehydes, ketones and glycols from secondary alcohols and ketones with minor amounts of glycol from tertiary alcohols. Carbon monoxide and water were formed in all cases. The products are consistent with the principal bond rupture at the carbinol carbon atom, with the reactivity of such carbinol bonded groups exhibiting the order $H > C_2H_5 > CH_3$ in the alcohols studied. The mechanism of formation of some of the products has been discussed. A.

541.15

1334. Hydrogen yields in the radiolysis of aqueous solutions. H. A. SCHWARZ, J. P. LOSEE, JR AND A. O. ALLEN. *J. Amer. Chem. Soc.*, **76**, *No.* 18, 4693–4 (*Sept.* 20, 1954).

The yield of molecular hydrogen from irradiation of various neutral and alkaline aqueous solutions by γ-rays or hard X-rays is now found to be 0·45 molecule per 100 eV, independent of temperature from 4 to 65°. It is unchanged by addition of 0·4 M NaCl

but is lowered by addition of H_2SO_4. In acid solutions of potassium iodide, additional formation of hydrogen occurs, which is suppressed by the presence of iodine; the additional hydrogen is believed to arise from an acid-dependent oxidation of iodide by H atoms, as postulated by Weiss. A.

541.15

1335. Yields of hydrogen peroxide in the decomposition of water by cobalt γ-radiation. I. Effect of bromide ion. T. J. Sworski. *J. Amer. Chem. Soc.*, **76**, *No.* 18, 4687–92 (*Sept.* 20, 1954).

When air-saturated KBr solutions are subjected to cobalt γ-radiation, the initial yield of H_2O_2 is dependent upon the concentration of KBr. It is proposed that the initial yield of H_2O_2 in KBr solutions containing O_2 is equal to "$F + 2E$" when KBr is present in concentrations greater than 10^{-5} molar. The "molecular" yield of H_2O_2 (formed by the combination of OH radicals in regions of high ionization density) is 0·75 molecular per 100 eV in sulphuric acid solutions at a pH of 2 and 0·78 molecule per 100 eV in 0·8 N sulphuric acid. A mechanism is presented in which KBr (even at concentrations as low as 10^{-5} molar) decreases the "molecular" yield of H_2O_2 by reaction of bromide ion with OH radical in regions of high ionization density. A.

DISPERSIONS . COLLOIDS . ADSORPTION 541.18

541.18.041.3 : 539.215.08

The aggregation of aerosols. *See Abstr.* 1284

541.182.2

1336. An improved halide ion-sensitive sampling surface for water aerosols. N. H. Farlow. *Rev. sci. Instrum.*, **25**, *No.* 11, 1109–11 (*Nov.*, 1954).

An improved type of transparent film sampling surface is presented for 25 μ to 400 μ dia. water droplets which contain halide ion concentrations greater than 0·5% by weight. A preliminary calibration of droplet size *v.* film spot size has been constructed. From the calibration data an experimental estimate is made of the chloride ion sensitivity per drop size on the film. A.

541.183

1337. The adsorption of ionic surfactants and their gegenions at the air–water interface of aqueous solutions. C. P. Roe and P. D. Brass. *J. Amer. Chem. Soc.*, **76**, *No.* 18, 4703–8 (*Sept.* 20, 1954).

This has been studied by means of surface tension measurements under conditions which permit a simple and exact interpretation. The significant result disclosed is that the surface excess in a surfactant solution does not vary with the concentration of surfactant in the bulk solution throughout a wide range just below the so-called critical micelle concentration. Composition of the adsorbed layer and thermodynamic properties of the dissolved surfactant are discussed. Radioactive tracer measurements on solutions of a labelled surfactant have been found to confirm the conclusions reached from surface tension measurements. A new technique for the direct tracer study of adsorption on solid surfaces is described and some results are presented. A.

541.183

1338. Charge-transfer-no-bond adsorption. F. A. Matsen, A. C. Makrides and N. Hackerman. *J. chem. Phys.*, **22**, *No.* 11, 1800–3 (*Nov.*, 1954).

The theory of charge-transfer complex is applied to adsorption on metals and semiconductors. The heat of adsorption at zero coverage is given in terms of the ionization energy of the adsorbate, the electronic work function of the adsorbent, an image energy and an interaction energy. For metals a linear relationship between heat (at zero coverage) and extent of adsorption is deduced from two of the simpler forms of theoretical isotherms. The functional dependence of the extent of adsorption on the ionization energy of the adsorbate is thus obtained. The treatment for semiconductors is modified to take into account the space charge generated in the semiconductor on adsorption. This treatment is shown to be consistent with reported experimental data for adsorption on iron powder of long-chain nitriles, esters, alcohols, amines and thiols. A.

CHEMICAL STRUCTURE 541.2/.6

541.623

1339. Study of tautomerism and the hydrogen bond by means of infrared spectroscopy. L. A. Duncanson. *J. Phys. Radium*, **15**, *No.* 10, 702–4 (*Oct.*, 1954) In French.

541.64

1340. Size distribution analysis in plasma extender systems. I. Gelatin. J. W. Williams, W. M. Saunders and J. S. Cicirelli. *J. phys. Chem.*, **58**, *No.* 9, 774–82 (*Sept.*, 1954).

Sedimentation analyses provide means for the determination of solute molecular weight and of distribution of molecular weights in systems of polyelectrolytes in proper solutions. The equilibrium method gives absolute molecular weights, while the velocity studies give valuable data about the actual form of the distribution curve. The combination of the two approaches, in effect a calibration of sedimentation constant in terms of molecular weight, serves several useful purposes. The application of such analyses to gelatin solutions establishes the fact that for the large molecules the sedimentation constant is closely proportional to the square root of the molecular weight. This fact and the intrinsic viscosity–molecular weight behaviour lead one to assert that the gelatin molecules in saline solution exist in the form of random coils, with the solvent being entrapped to a considerable extent. A.

541.64

1341. The synthesis of block copolymers in a flow system. J. A. Hicks and H. W. Melville. *Proc. Roy. Soc. A*, **226**, 314–35 (*Nov.* 23, 1954).

The principle of the method is to start off polymerization of a vinyl compound in a system in which the liquid flows down a capillary tube at a regulated rate. Initiation of the reaction is made at a fixed point in the capillary tube, and the radicals so formed are allowed to grow until a specified size is reached.

These radicals are then allowed to flow into a large excess of another monomer in which new environment polymerization is completed so that one-half of the molecule is synthesized in the capillary and the other in the receiver attached to that capillary. The systems studied are butylacrylate-styrene and acrylonitrile-styrene. In order to achieve the synthesis of reasonable amounts of material for examination a special apparatus has been designed to initiate polymerization photochemically at extremely high rates. This is done by illuminating a 1 mm capillary tube by means of a specially designed elliptical reflector from a capillary mercury arc lamp. The lamp and the capillary are at the two foci of the ellipse. By using this arrangement radical concentrations 10 000 times greater than that normally achieved have been obtained, and methods have been developed to demonstrate that it is possible to arrange matters to have a solution of polymer radicals in monomer issuing from the capillary tube. The kinetics of reaction in a flow system have been worked out, and incidentally the method provides an additional means whereby the absolute velocity coefficients of radical polymerization can be determined. A.

CHEMICAL ANALYSIS 543/545

545.822

1342. Simultaneous determination of sodium, potassium, calcium, magnesium and strontium by a new multichannel flame-spectrometer. B. L. VALLEE. *Nature* [*London*] **174,** 1050–1 (*Dec.* 4, 1954).

An instrument for chemical analysis of biological specimens has been made. It uses an oxy-hydrogen flame and a grating in a stigmatic Wadsworth mounting. Five photomultipliers, connected to microammeters, are set on lines of Mg, Na, K and Sr, and on a CaO band at 5459 Å. Calibration is linear over a range of 1–1000 with a precision of 1–3%. Interference of one element with another is attributed to a heterochromatic background, and as this is proportional to the concentration of the radiating species, the backgrounds are additive and can be corrected for readily. A. G. GAYDON

545.827

1343. Mass spectra of the deuteroethylenes. V. H. DIBELER, F. L. MOHLER AND M. DE HEMPTINNE. *J. Res. Nat. Bur. Stand.*, **53,** *No.* 2, 107–11 (*Aug.*, 1954).

CRYSTALLOGRAPHY 548

548.1

1344. Paper representations of the noncubic crystal classes. L. I. SCHIFF. *Amer. J. Phys.*, **22,** *No.* 9, 621–2 (*Dec.*, 1954).

It is shown that the full symmetries of twenty-seven of the thirty-two crystal classes, all except the five cubic classes, can be exhibited by suitably marked pieces of paper or cardboard. It is necessary to use both sides of the paper, and to exploit its small but finite thickness. A.

548.55

1345. A device for preparing single crystal spheres. J. J. HOEKSTRA, B. KE AND D. TRIVICH. Letter in *Rev. sci. Instrum.*, **25,** *No.* 10, 1033–4 (*Oct.*, 1954).

A lathe attachment consisting of a dowel pin of the desired sphere diameter and a special tool holder equipped with a cutter and follower is described and its principle of operation discussed. S. WEINTROUB

548.574

1346. Etching of single crystal germanium spheres. R. C. ELLIS, JR. *J. appl. Phys.*, **25,** *No.* 12, 1497–9 (*Dec.*, 1954).

Spheres of single crystal germanium have been ground and etched. A series of polyhedra, consistent with the stability of the various crystal planes of germanium was obtained. Only (111) plane twins were found in germanium using this method. A.

ATOMIC AND X-RAY CRYSTALLOGRAPHY 548.7

548.7 : 536.413.2

1347. On the thermal expansion of crystals. V. L. SHMARTS. *Zh. éksper. teor. Fiz.*, **27,** *No.* 1(7) 62–8 (1954) In Russian.

Using some simple calculations due to Frenkel the present formulae for the coefficients of linear expansion of metals and ionic crystals can be revised. Correlation is made between the thermal capacity, the coefficient of expansion and the lattice parameter of the crystal, thus generalizing the law of Grüneisen. Experimental and theoretical values are presented in table form. Ferromagnetics are not included.

W. BARDSLEY

548.7 : 539.31

1348. Moment singularity analysis of vibration spectra. M. LAX AND J. L. LEBOWITZ. *Phys. Rev.*, **96,** *No.* 3, 594–8 (*Nov.* 1, 1954).

The frequency distribution of a crystal is approximated by combining Van Hove's determination of its analytical nature and Montroll's method of moments. The function $G(\omega^2)$ is represented by an expression with the correct behaviour at the singularities and at the maximum and minimum frequencies. The behaviour between singular points is adjusted smoothly by leaving n undetermined parameters. These parameters are then fixed by using the correct first n moments. As a test, this procedure was applied to the two-dimensional square lattice with nearest and next nearest neighbour interactions, solved exactly for a particular case by Montroll. The approximated distribution function had the right form at the end points, contained terms of the appropriate logarithmic form, and a jump function (with known coefficients). It also included Legendre polynomials with unknown coefficients, which were determined by moments. The difference between the exact and approximate distribution functions was a few per cent using only

the zeroth moment (normalization). Using higher moments produced a gradual increase in accuracy. A.

548.7

1349. Exciton bands in crystalline benzene. D. Fox and O. Schnepp. *Phys. Rev.*, **96**, *No.* 5, 1196 (*Dec.* 1, 1954).

The structures of the two lowest exciton bands of crystalline benzene have been investigated. The separations are given between those band levels to which optical transitions are allowed from the crystal ground state. A.

548.7 : 537.533.74

Scatter of high-energy electrons in crystals. *See Abstr.* 987

548.7

1350. Thermal ionization of impurities in polar crystals. I. Formal theory. H. D. Vasileff. *Phys. Rev.*, **96**, *No.* 3, 603–9 (*Nov.* 1, 1954).

The method of O'Rourke is used to obtain an expression for the thermal ionization rate of an impurity in a polar crystal. The interaction energy of the trapped electron with the optical vibrational modes is assumed to be linear in the normal vibrational co-ordinates of the lattice. The eigenvalue equations and perturbation of the Born–Oppenheimer adiabatic potential method are employed, leading to a result identical to that of Huang and Rhys. Multiphonon transitions occur only when the configurational constant $S \neq 0$. An approximation of simple form, for the transition rate, can be made only for low temperatures, where the frequency factor s is independent of temperature. A.

548.7 : 537.311.3

1351. Statistics of the occupation of dislocation acceptor centres. W. T. Read, Jr. *Phil. Mag.*, **45**, 1119–28 (*Nov.*, 1954).

This is a sequel to a paper [Abstr. 9754 (1954)] dealing with the acceptor centres associated with dislocations in germanium. Some further approximations are now presented that take account of the non-uniform spacing of accepted electrons along the dislocation. The case where the dislocation acceptors have a range of energy levels (rather than a single level) is also treated. The several approximations are compared by plotting the fraction of acceptors that are full *v.* temperature for a particular example. A.

548.7 : 535.371

Luminescence of *F*-centres in alkali-halide crystals. *See Abstr.* 859

548.73/.74

X-ray and electron investigation of materials. See also under "Structure of solids." Decimal classification 539.26/.27.

548.73

1352. Summarized proceedings of a conference on X-ray analysis—London, November, 1953. U. W. Arndt and J. B. Nelson. *Brit. J. appl. Phys.*, **5**, *No.* 12, 417–25 (*Dec.*, 1954).

The Autumn Conference of the X-ray Analysis Group of The Institute of Physics. The first day's session was devoted to the subject of film and counter methods and the second day's to identification by X-ray analysis. The papers presented and the discussion on them are summarized. A.

548.732

1353. The X-ray scattering from a hindered rotator. III. M. Atoji and W. N. Lipscomb. *Acta cryst.*, **7**, *Pt* 11, 726–9 (*Nov.*, 1954).

For Pt II, see Abstr. 8069 (1953). The average structure factor for a three-dimensional hindered rotator is derived by using a group-theoretical generalization of spherical harmonics. The final relation is general, and is easily specialized for the usual potential fields expected in the more symmetrical crystals. A.

548.733

1354. A single mounting for all three axes. W. E. Love and D. Sayre. Letter in *Rev. sci. Instrum.*, **25**, *No.* 8, 830–1 (*Aug.*, 1954).

The crystal is held on a glass fibre which makes the same angle with all three axes: the fibre is mounted so that any axis of the crystal can be brought into the required direction by rotating it. A. R. STOKES

548.733

1355. A proposed method for electronic intensification of single-crystal X-ray diffraction images. A. R. Lang. Letter in *Rev. sci. Instrum.*, **25**, *No.* 10, 1032–3 (*Oct.*, 1954).

Describes the application of the Philips X-ray image intensifier [Abstr. 1319 (1953)] to X-ray diffraction, and in particular to moving-film methods such as that of de Jong and Bouman. A. R. STOKES

548.733

1356. Suggested necessary conditions for successful use of the stationary crystal integrated reflection measuring method with the counter spectrometer. A. R. Lang. Letter in *Rev. sci. Instrum.*, **25**, *No.* 10, 1039–40 (*Oct.*, 1954).

The X-ray tube focus generally has a banded structure. It is shown that the plane containing the incident beam direction and the crystal-plane normal must be parallel to the direction of these bands.

A. R. STOKES

548.734

1357. Crystal settings for upper level photography, precession method. L. V. Azaroff. Letter in *Rev. sci. Instrum.*, **25**, *No.* 9, 928–9 (*Sept.*, 1954).

The region of reciprocal space covered by one setting is considered, and hence the number of settings required to cover the whole reciprocal lattice out to one r.l.u. A. R. STOKES

548.734

1358. An X-ray diffraction method for the study of substructure of crystals. J. Intrater and S. Weissmann. *Acta cryst.*, **7**, *Pt* 11, 729–32 (*Nov.*, 1954).

A double-crystal diffractometer method using a Geiger counter and supplementary film technique has been described. The analysis of the multi-peaked rocking curves obtained from bent, coarse-grained aluminium established a correlation between intensity maxima and adjacent lattice regions giving rise to them. The tilt between adjacent subgrains was determined and the existence of substructural domains within the subgrain was shown. A.

548.734

1359. X-ray diffraction by close-packed crystals with "growth-" and "deformation or transformation stacking faults" assuming an "*n*-layer influence." R. GEVERS. *Acta cryst.*, **7**, *Pt* 11, 740–4 (*Nov.*, 1954).

The general theory is developed of the X-ray diffraction effects exhibited by close-packed crystals containing both "growth-" and "deformation or transformation stacking faults." A general "*n*-layer influence" is postulated for the distribution of the "faults" of the first and also for those of the second type. This means that: (1) the probability α_l for a layer to be *k*-arranged in the original pattern of close-packed layers, depends on the arrangement of its *n* predecessors; (2) the probability β_j for a layer to be a "deformation or transformation stacking fault" depends on the arrangement of "correct" and "fault" layers in the sequence of its *n* predecessors. A general expression can then be derived for the reciprocal-lattice X-ray intensity distribution as a function of the 2^{n-2} parameters α_l and the 2^n parameters β_j. The formulae are given for the special cases (*a*) an irregular pattern in which the "faults of the second type" are randomly distributed, or are not present; (*b*) an irregular pattern obtained by introducing "faults of the second type" into an hexagonal or cubic close-packed pattern with randomly distributed "faults of the first type"; (*c*) an irregular pattern obtained by introducing "faults of the second type" into a regular cubic close-packed pattern. For the last case the general expression for the X-ray intensity is given, as it differs from that which covers all the other cases. A.

548.735

1360. A theoretical possibility of correcting the collimation error in small-angle X-ray scattering. K. KRANJC. *Acta cryst.*, **7**, *Pt* 11, 709–10 (*Nov.*, 1954).

A general solution for correcting the collimation error in small-angle X-ray scattering is considered. The experimentally obtained intensity function can be expressed analytically as the convolution of the correct intensity function and the intensity distribution on the trace of the primary beam in the film. The correction of the experimental scattering curve is possible by using the convolution theorem for multiple Fourier transforms. A.

548.735

1361. Sign determination for *pgg*, *p4g* and certain other space groups. M. M. WOOLFSON. *Acta cryst.*, **7**, *Pt* 11, 721–5 (*Nov.*, 1954).

An analytical method is described for finding the probable signs of structure factors of even indices for the (two-dimensional) space groups *pgg* and *p4g* from a knowledge of the intensities alone. It is shown that the sign of $U_{2h,2k}$ is probably the sign of $\sum_{h'}\sum_{k'} W_{h'k'}(-1)^{h'+k'}$, where

$$\begin{aligned} W_{h'k'} = \tanh\,(N|U_{2h,2k}U_{h+h',k}U_{h-h',k}|) \\ \times \tanh\,(N|U_{h+h',k}U_{h,k+k'}U_{h'k'}|) \\ \times \tanh\,(N|U_{h-h',k}U_{h,k+k'}U_{h'k'}|) \\ + \tanh\,(N|U_{2h,2k}U_{h,k+k'}U_{h,k-k'}|) \\ \times \tanh\,(N|U_{h,k+k'}U_{h+h',k}U_{h'k'}|) \\ \times \tanh\,(N|U_{h,k-k'}U_{h+h',k}U_{h'k'}|), \end{aligned}$$

and the summation is carried out over all h' and k' contained in two adjacent quadrants. The principles are extended to other space groups and it is shown that the restriction of even indices may be overcome. An example of the application of the method is given, the reliability of the results is discussed and some possible extensions of the method are suggested. A.

548.735

1362. On the visual estimation of X-ray reflexion intensities from upper-level Weissenberg photographs. D. C. PHILLIPS. *Acta cryst.*, **7**, *Pt* 11, 746–51 (*Nov.*, 1954).

Formulae are derived which govern the variations in reflection spot area observed on upper-level Weissenberg photographs. It is shown that they can be used in a routine correction of intensities visually estimated from such photographs. A.

548.735

1363. A method of determining the relative positions of molecules using Fourier-transform principles. C. A. TAYLOR. *Acta cryst.*, **7**, *Pt* 11, 757–63 (*Nov.*, 1954).

After the shape and orientation of a molecule have been determined by Patterson, Fourier-transform, or other methods its position in the unit cell must be found. Details are given of a method by which this has been done, and examples are given for projections of structures which have the plane groups p2 and *pgg*. Some theoretical implications and possible lines of development are indicated. A.

548.735 : 539.153.4

Some calculations of atomic form factors. *See Abstr.* 1128

548.735.44

1364. Quantitative relations in Fourier expansions of the electron density of crystals. B. K. VAĬNSHTEĬN. *Zh. éksper. teor. Fiz.*, **27**, *No.* 1(7) 44–61 (1954) In Russian.

The Fourier expansion based on X-ray analysis yields the electron density in the crystal lattice, the maxima (peaks) of which correspond to the atoms. The so-called integral characteristics of the electron density distribution of the atom are the electron density at the centre of the atom (height of the peak), the total number of electrons in the atom and the MS value of the electron density. For an estimate of the precision of the determination of the coordinates of the atoms the value of the second derivative at the peak and the MS value of the first derivative of the electron density are also needed. All the characteristics referring to the crystal may be calculated with a satisfactory accuracy from the characteristics of the atoms forming the lattice. Analogous quantities occur also in the projection of the electron density. The integral characteristics of the atoms are calculated as integrals of the corresponding functions in the inverse space and may eventually be expressed by a simple function of the atomic number of the form *kZ*. The concrete form of these characteristics is found for various MS displacements of the atoms from their equilibrium positions, for two- and three-dimensional expansions. Problems of the precision of the *F* and F^2 expansions are considered. B. F. KRAUS

548.736.1

1365. An X-ray study of the substructure of fine-grained aluminum. S. WEISSMANN AND D. L. EVANS. *Acta cryst.*, **7**, *Pt* 11, 733–7 (*Nov.*, 1954).

Details of the grain substructure of fine-grained

aluminium have been revealed by the X-ray double-crystal diffractometer by means of a multiple-exposure technique. The data obtained are used to compute statistical parameters that are a measure of the angular tilt between adjacent subgrains and of the angular misalignment of the lattice within a subgrain. An interpretation of the observed data as functions of lattice bending is presented. A.

548.736.1

1366. X-ray study of the graphitization of carbon black. C. R. Houska and B. E. Warren. *J. appl. Phys.*, **25**, *No.* 12, 1503–9 (*Dec.*, 1954).

A picture of the early stage of graphitization of a carbon black has been obtained from an X-ray study of a Fine Thermal (FT) carbon black heated for two hours at 2300°C. Nearest neighbour pairs of layers take on the graphite relation independently, producing both ABA and ABC sequences. There are two nearest neighbour layer spacings 3·35 Å and 3·44 Å corresponding to pairs with the graphite relation and pairs with random orientation. The (00*l*) peaks must be corrected for the distortion broadening resulting from the two spacings, to obtain the parallel layer group thickness L_c. The probability for the ordering of nearest neighbour layers P_1 is defined as the "degree of graphitization." A logarithmic plot is used for a rapid determination of P_1 and the layer diameter L_a from the modulated two dimensional (*hk*) reflections. A.

548.736.6

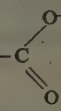
1367. X-ray study of fibrous quartz. C. V. Raman and A. Jayaraman. *Proc. Indian Acad. A*, **40**, *No.* 3, 107–9 (*Sept.*, 1954).

The results of optical and X-ray examination of specimens of fibrous quartz from the Bababudan Hills in Mysore are described. They indicate that the material may be described as polycrystalline quartz with a strongly preferred orientation for the crystallographic *c*-axis along the length of the fibres. A.

548.737

1368. The crystal structure of polyethylene terephthalate. R. de P. Daubeny, C. W. Bunn and C. J. Brown. *Proc. Roy. Soc. A*, **226**, 531–42 (*Dec.* 7, 1954).

The crystal structure of polyethylene terephthalate (Terylene) has been determined by the interpretation of the X-ray diffraction patterns given by drawn fibres. The unit cell, which contains one chemical unit, $-CO.C_6H_4.CO.O.(CH_2)_2O-$, is triclinic, with $a = 4{\cdot}56$ Å, $b = 5{\cdot}94$ Å, $c = 10{\cdot}75$ Å, $\alpha = 98\frac{1}{2}°$, $\beta = 118°$, $\gamma = 112°$. This gives the density of the crystals as 1·455 g/cm³. If it is assumed that the density of amorphous regions in partly crystalline material is the same as that of the entirely amorphous material (1·335), the proportion by weight of crystals in ordinary drawn yarn (density 1·39) is 48%, and in specimens of the highest recorded density (1·41) it is 64·5%. These figures are, however, lower limits; if, as is likely, the density of amorphous regions in partly crystalline specimens is lower than 1·335, the proportions of crystalline material are higher than the figures given. The positions of atoms in the crystals have been deduced from the relative intensities of X-ray diffractions; approximate positions were found by trial-and-error methods, and refinement was then effected by calculations of electron densities, using the three-dimensional Fourier synthesis method. The molecules are nearly planar in configuration. Distances between atoms in neighbouring molecules are all normal Van der Waals contact distances; there is therefore no structural evidence for any unusually strong forces between the molecules. This conclusion is in agreement with that based on an estimate of the cohesion energy, which is very nearly the same as that of a comparable aliphatic polyester, polyethylene adipate. The high melting-point of polyethylene terephthalate in comparison with aliphatic polyesters is therefore not due to strong forces between the molecules; it is attributed to the rigidity



of the aromatic ring with its attached groups.

In most drawn fibres of this polymer, the crystals do not have their *c*-axes (those parallel to the chain molecules) exactly parallel to the fibre axes; they are tilted in a precisely defined crystallographic direction, such that the $\bar{2}30$ plane remains vertical and the inclination of the 101 plane to the fibre axis increases. This is especially well defined in fibres heated to 210°c and allowed to relax, the tilt angle being then about 5°. In principle it is expected that polymer crystals of triclinic symmetry would be tilted, but it is not clear what determines the crystallographic direction of tilt. Tilted crystal X-ray diffraction photographs played an important part in the structure determination. A.

548.74 : 539.27

An electron diffraction specimen chamber with a specimen vacuum lock. *See Abstr.* 1298

GEOPHYSICS 55

550.341

1369. Wavelet contraction, wavelet expansion, and the control of seismic resolution. N. Ricker. *Geophysics*, **18**, *No.* 4, 769–92 (*Oct.*, 1953).

The general problem of seismic resolution is discussed. A seismogram, free from distortions, is an elaborate *wavelet complex*, and the analysis of a seismogram consists in breaking it down into its wavelet components. Distortions introduced by conventional seismographs are discussed and the conditions to be imposed upon seismic apparatus for distortionless wavelet transmission are set down. Three distortionless systems are possible: flat response; the wavelet contractor; and the wavelet expander. Wavelet contraction is discussed, whereby the individual wavelets which go to make up the seismogram may be contracted to a lesser breadth without altering the relative arrival times of the wavelet centres.

Laboratory studies of the wavelet contractor are described and examples of wavelet contraction and the resolution of wavelet complexes are given. A description of the wavelet contracting seismograph used in the evaluation of the device in the field is given and results of the evaluation programme are discussed. The wavelet contractor delineates subsurface formations with greater precision than does the conventional seismograph and it is able to carry pinchouts and truncations farther than is possible with conventional seismographs. A.

550.341

1370. Seismic recording on magnetic tape. G. B. Loper and R. R. Pittman. *Geophysics*, **19**, *No.* 1, 104–15 (*Jan.*, 1954).

A system of recording and reproducing exploration seismograms on magnetic tape is described. Geophones and amplifiers with broad-band response, approximately 4–300 c/s, are used to channel the seismic signals to a 13-track tape recorder. The magnetic tape is 1 in. wide. One of the tracks is used to record a time reference signal. Each broad-band recording is formed into an endless loop and played back in repeating fashion. The signals are fed through a flexible system of filtering and mixing, then examined on the screen of a 12-trace cathode-ray oscilloscope. The sweep of the oscilloscope is synchronized with the loop and, by varying the sweep speed, the entire record, or an expanded portion thereof, is held stationary on the screen. Conventional paper records of the modified record as reproduced on the screen are finally made with a regular seismic camera. Played-back records with variations of filtering and mixing are shown in order to illustrate the potential usefulness of the technique. A.

550.341

1371. A three-dimensional seismic wave model with both electrical and visual observation of waves. J. F. Evans, C. F. Hadley, J. D. Eisler and D. Silverman. *Geophysics*, **19**, *No.* 2, 220–36 (*April*, 1954).

The short wavelengths required in a seismic model to give wave-front patterns geometrically similar to those in a large prototype (the earth) can only be obtained by using high-frequency sound waves. As sources and detectors of such high-frequency waves, piezoelectric crystals are used, primarily because under identical stimuli they are capable of almost perfect duplication. Such duplication is made use of in displaying on an oscilloscope stationary patterns which are characteristic of transient particle motion at a point in the model. Also, it has made possible the direct visual observation of transient wave fronts in transparent models, techniques for which are described, and sample photographs given. As an example of quantitative use of the described model techniques, the results are presented showing symmetric and anti-symmetric wave propagation in a free elastic plate. Good agreement is found between many features of the experimental record and theoretical predictions. A.

550.341

1372. The method of Cagniard in seismic pulse problems. C. H. Dix. *Geophysics*, **19**, *No.* 4, 722–38 (*Oct.*, 1954).

The main procedures used by Cagniard (1939) to calculate seismic pulse motion have been carried through for the case of a point source in an infinite medium. This relatively simple case serves as a basis for a simplified exposition of Cagniard's method. A.

550.372

1373. Mutual coupling of loops lying on the ground. J. R. Wait. *Geophysics*, **19**, *No.* 2, 290–6 (*April*, 1954).

The theory of a method of measuring electrical ground constants by mutual coupling of loops is outlined. Curves are given in parametric form showing the dependence of the mutual impedance on conductivity, dielectric constant, frequency, and separation. An expression is derived in the appendix for the field of a circular wire loop laid on a homogeneous conducting ground. A.

550.38

1374. Homogeneous dynamos and terrestrial magnetism. E. Bullard and H. Gellman. *Phil. Trans A*, **247**, *No.* 928, 213–78 (1954).

The main object of the paper is to discuss the possibility of a body of homogeneous fluid acting as a self-exciting dynamo. The discussion is for the most part confined to the solution of Maxwell's equations for a sphere of electrically conducting fluid in which there are specified velocities. Solutions are obtained by expanding the velocity and the fields in spherical harmonics to give a set of simultaneous linear differential equations which are solved by numerical methods. Solutions exist when harmonics up to degree four are included. The convergence of the solutions when more harmonics are included is discussed, but convergence has not been proved. The simultaneous solution of Maxwell's equations and the hydrodynamic equations has not been attempted, but a velocity system has been chosen that seems reasonable from a dynamical point of view. A parameter in the velocity system has been adjusted to satisfy the conservation of angular momentum in a rough way. Orders of magnitude are derived for a number of quantities connected with the dynamo theory of terrestrial magnetism. It is concluded that the dynamo theory does provide a self-consistent account of the origin of the earth's magnetic field and raises no insuperable difficulties in other directions. A.

550.383 : 525.241

1375. On the increase of the earth's dipole moment. H. G. Macht. *J. geophys. Res.*, **59**, *No.* 3, 369–76 (*Sept.*, 1954).

The problem of whether the earth's magnetic moment M is increasing or still decreasing cannot at present be definitely answered from a critical review of recent literature. From an investigation of Vestine's successive analyses of the geomagnetic secular variation since around 1910, the conclusion is reached that M, after having passed through a minimum a few years ago (probably between 1945 and 1952), is beginning to recover at present. A semi-quantitative explanation of the secular change of M is afforded on the basis of a physical model of the main geomagnetic field (conception of two eccentric dipoles) as developed in an earlier publication. The hypothesis is advanced of quasi-periodic cycles of about three centuries, with alternating demagnetization and induction (remag-

netization) processes in the earth giving rise to corresponding cycles of decrease and increase of *M*. A.

550.384

1376. Forecasting geomagnetic perturbations. J.-C. Pecker and W. O. Roberts. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 10, 635–7 (*Sept.* 6, 1954) In French.

To predict the date and intensity of maxima three kinds of extrapolation were used: (*a*) for each individual series of maxima the periodicity is extrapolated on a Bartels-type diagram, (*b*) intensity of successive maxima are extrapolated allowing for the tendency to pass a maximum in March or September, (*c*) the reappearance each year of recurring series at fixed heliographic longitudes is used to predict new series. The predictions agree remarkably with observations for months ahead for the position of the maxima except for its more rapid disappearance, and there is good agreement for intensity. The method may not apply so successfully for periods of maximum solar activity because of the masking by large magnetic storms. The requirements of a more complete method for correlation between geomagnetic activity and solar phenomena are discussed. R. S. READ

550.384 : 551.594.5

1377. Time sequences and spatial relations in auroral activity during magnetic bays at College, Alaska. J. P. Heppner. *J. geophys. Res.*, **59**, *No.* 3, 329–38 (*Sept.*, 1954).

At College (Fairbanks), Alaska, simple magnetic disturbances of negative bay type are closely related to a sequence of change in the type of auroral activity. General features of the relationship indicate that auroral forms are not independent of the electromotive force responsible for the intense auroral-zone currents. Following the major $-\Delta H$ disturbance, a short interval of $+\Delta H$ disturbance is observed; this cannot be explained by the existing idealized current-systems for the auroral zone. A.

550.387

1378. On the relation between telluric currents and the earth's magnetic field. J. R. Wait. *Geophysics*, **19**, *No.* 2, 281–9 (*April*, 1954).

The validity of Cagniard's analysis [Abstr. 9804 (1954)] of the behaviour of telluric earth currents is questioned in view of the fact that the harmonic components of the electric field and the magnetic field tangential to the ground are only proportional to one another if the fields are sufficiently slowly varying over the surface of the ground. His result is extended to include the effects of a layered ground with both conductivity and susceptibility variations. Finally the corresponding transient problem is solved for a two-layer horizontally stratified earth. A.

550.93

1379. U.S. geological survey radiocarbon dates. I. H. E. Suess. *Science*, **120**, 467–73 (*Sept.* 24, 1954).

Lists the dates obtained by the method described in Abstr. 9805 (1954), for samples of unknown age. The measurements were made over the period Oct., 1953 to April, 1954.

550.93 : 539.165

The potassium–argon method of geological age determination. *See Abstr.* 1154

551.1 : 550.34

1380. Crustal structure from seismic exploration. M. A. Tuve, H. E. Tatel and P. J. Hart. *J. geophys. Res.*, **59**, *No.* 3, 415–22 (*Sept.*, 1954).

The exploration of the earth's crust with seismic waves has an accuracy limited by conversion-scattering and the scattering of surface and interior irregularities. These scattering effects produce signals masking the smaller signals which might be present from minor structural features. Consequently, only the broader aspects of crustal structure may be observed with the seismic method. Data in the form of travel-time plots may be fitted with a family of theoretical curves derived from a group of velocity *v*. depth relationships of a somewhat similar nature. These show that the wave velocity is greater at greater depths within the crust. The demarcation between crust and mantle (where the compressional velocity is 8 km/sec) may be abrupt—less than 250 metres—or, as an extreme, may be gradual—within several kilometres. More complex velocity *v*. depth functions may be made to fit the data, but these require more complex assumptions. For example, it is not necessary to assume the existence of discrete systematic intermediate layering to fit the data; smooth continuous functions suffice and, in addition, no systematic reflections have ever been observed from such intermediate layers. A.

ATMOSPHERE . METEOROLOGY 551.5

551.501.8

1381. A technique for sweep frequency polarization measurements at low frequencies. E. L. Kilpatrick. *J. geophys. Res.*, **59**, *No.* 3, 345–9 (*Sept.*, 1954).

A technique for simultaneously recording the polarization and virtual height of sweep frequency ionospheric echoes is described. The representative polar and phase diagrams of each echo are recorded on photographic film, with displacement in one direction proportional to virtual height and in the other direction proportional to frequency. Several sample records are shown, together with a block diagram of the equipment. A.

551.508.7 : 551.571.7

1382. Measurement of atmospheric humidity up to 35 kilometers. C. J. Brasefield. *J. Meteorol.*, **11**, *No.* 5, 412–16 (*Oct.*, 1954).

Measurements have been made of atmospheric humidity to altitudes as high as 35 kilometres by means of a hygristor—a humidity-sensitive radiosonde accessory which is essentially a miniature version of the Foxboro Dewcel. The hygristor indicates ambient dewpoint so long as the relative humidity is above a threshold which is roughly 15%. When the relative humidity is below the threshold value, the hygristor indicates the upper limit of possible dewpoint values. Since the relative humidity in the stratosphere was usually very low, most of the humidity data obtained with the hygristor above the tropopause are in the latter category. However, on several occasions when precise values of dewpoint were obtained in the stratosphere, if was found that the dewpoint increased above the tropopause and was even higher than the

temperature of the tropopause at altitudes near 20 kilometres. A.

551.510.41 : 551.594.21

1383. Relations between atmospheric ozone and storms. A. VASSY. *C.R. Acad. Sci.* [*Paris*] **239,** *No.* 20, 1309–11 (*Nov.* 15, 1954) In French.

Measurements of ozone content at ground level are continuously made at Val-Joyeux and values obtained range from indetectable to a volume concentration of $7{\cdot}3\times10^{-8}$. At the same station records are kept of storm discharges by an atmospheric recording machine. It has been shown that high ozone content is associated with storms but occurs on the average three hours before the storm starts to cause atmospherics. J. M. HOUGH

551.510.534

1384. On new investigations of the ozone layer and its variations. H. K. PAETZOLD. *J. geophys. Res.*, **59,** *No.* 3, 365–8 (*Sept.*, 1954).

The various methods for determination of ozone distribution are discussed, among them that of utilizing lunar eclipse. With the latter method and under suitable conditions, ozone distribution can be obtained at latitudes where otherwise observations would be difficult to make. Results for different latitudes and altitudes are given. A.

551.510.535

1385. Measurements in the *E*-layer with the Navy Viking rocket. J. E. JACKSON. *J. geophys. Res.*, **59,** *No.* 3, 377–90 (*Sept.*, 1954).

Ordinary and extraordinary indices of refraction at 4·274 Mc/s were measured in the region surrounding the rocket. From these basic data, it was possible to determine the electron density continuously from 95 to 165 km and to show that the Lorentz polarization term should not be used at 4 Mc/s. In addition, the rapid decay to extinction of the extraordinary ray between 136 and 142 km was used to compute a value of 0·488 oersted for the earth's magnetic field at 139 km and to set an upper limit of 10^4 per second for the electron collision frequency at 139 km. The results of the Viking flight and also those of previous flights indicate a rapid increase in electron density beginning at 92 km and ending near 110 km. Between 110 and 165 km, the Viking data show that the electron density increased very slowly from $1{\cdot}3\times10^5$ el/cm^3 to $1{\cdot}8\times10^5$ el/cm^3. This distribution and similar evidence previously obtained suggest that during the daytime the *E*-layer probably remains dense up to the *F*-layers. A.

551.510.535

1386. Recombination in the lower ionosphere. A. P. MITRA AND R. E. JONES. *J. geophys. Res.*, **59,** *No.* 3, 391–406 (*Sept.*, 1954).

The problem of recombination of electrons and ions in the lower ionosphere is studied both experimentally and theoretically. The experimental study involving, among others, the measurements on phase height, polarization and absorption at 150 kc/s, allows formulation of a tentative distribution of ionospheric recombination coefficient over the range of 60 to 110 km. On the basis of this model, the theories of recombination in the lower ionosphere are examined in detail. The problem of recombination during sudden ionospheric disturbances is also studied. A.

551.510.535

1387. The applicability of continuous-fluid theory in the higher atmosphere. D. G. YERG. *J. Meteorol.*, **11,** *No.* 5, 387–91 (*Oct.*, 1954).

The validity of the concept of winds in the higher atmosphere is associated with the physical restrictions governing the selection of the infinitesimal volume, or mass element, used in the development of the equations of motion. Numerical criteria concerning the size of the mass element are presented and applied to the higher atmosphere. A modification of the equations of motion, to include higher-order pressure derivatives, appears necessary in the *F*-region. Consideration must be given to the special interpretation of the variables in such equations. An evaluation of pressure in an isothermal atmosphere suggests that the density decreases less rapidly with height above the *F*-region than in the standard equation. The results of the study imply an increased confidence in the use of conventional equations in the *E*-region and show a need for further study of basic relations in the *F*-region. A.

551.510.535

1388. Simultaneous ionospheric absorption measurements at widely separated stations. W. J. G. BEYNON AND K. DAVIES. *J. atmos. terrest. Phys.*, **5,** *No.* 5–6, 273–89 (*Nov.*, 1954).

Simultaneous normal incidence 2 Mc/s ionospheric absorption measurements made daily at noon at Slough and Swansea (230 km apart) have been compared. The same measuring technique has been employed at the two stations. The correlation between the two sets of measurements is generally high. The average correlation coefficients between daily observations are 0·85 and 0·81 for the winter and summer months respectively. Some measurements in which variations in the received signal intensity from c.w. senders at distances of 366 km and 666 km have been compared with normal incidence amplitude measurements on the equivalent frequency are also described. These, and the Slough–Swansea observations, give some indication of the progressive decrease with increasing distance in the degree of correlation between simultaneous ionospheric absorption measurements at different stations. The use of simple field strength recording as a quantitative measure of ionospheric absorption is briefly considered. A.

551.510.535

1389. F_2-layer regularities at Ibadan. N. J. SKINNER and R. W. WRIGHT. *J. atmos. terrest. Phys.*, **5,** *No.* 5–6, 290–7 (*Nov.*, 1954).

The mean daily variation throughout the year of n (the total electron content in a column of unit cross-section below the height of maximum ionization (h_m) in the F_2-layer) and N_m (the maximum electron density of the F_2-layer), show clearly that n behaves in a more regular manner than N_m. It is shown that in calculating n it is important to use values of the equivalent layer semi-thickness deduced assuming non-parabolic electron distributions where necessary. The Appleton–Beynon (1947) method for "parabolic"

layers is not, therefore, completely adequate in tropical regions. Inclusion of the contribution by the F_1-layer to the total electron content has no appreciable effect upon the regularity of the diurnal variation of n. A new method is described and used for deducing the coefficient of recombination (α), and the rate of ion production per cm^3 (q), from the daily variation of n. The pronounced sunset minimum in the virtual height of F_2, as reported by some observers, is discussed and considered to be largely spurious. An h_m and y_m histogram is plotted and is found to be dissimilar to that at Huancayo, and similar to that at College, Alaska. A.

551.510.535

1390. Ionospheric thermal radiation at radio frequencies. II. Further observations. F. F. Gardner. *J. atmos. terrest. Phys.*, **5**, *No.* 5–6, 298–315 (*Nov.*, 1954).

For Pt I, see Abstr. 2849 (1952). The results of a series of observations of 2 Mc/s radio noise over a period of about a year at a very quiet site are described. The noise received during the midday hours is thought to have been due almost entirely to ionospheric thermal radiation. The derived ionospheric temperatures ranged between about 200° and 250°K, varied appreciably from day to day and were lower and less variable in winter. During sudden ionospheric disturbances the ionospheric temperature increased by up to 40°K. This increase is probably due to a height change of the 2 Mc/s absorbing region. Polarization measurements showed that in September, 1951, the intensity of the extraordinary component, absorbed at the lower ionospheric level, corresponded to a temperature about 20°K higher than the ordinary. This established that the absorbing regions were then located at a level where the temperature decreased with height. Information on the location of the absorbing regions was obtained from an auxiliary set of pulse reflection measurements. The experimental observations can be explained reasonably in terms of a fixed temperature-height model, similar to that determined by rocket measurements, but having a minimum of 217°K at 80 km. A.

551.510.535

1391. Turbulence in the upper ionosphere. A. Maxwell. *Phil. Mag.*, **45**, 1247–54 (*Dec.*, 1954).

From the experimental data at present available it is shown that the Reynolds number in the upper F-region (300–400 km level) is of the order of 300. The region may therefore be turbulent. It is suggested that the high level diffracting screens which give rise to spread F-echoes and to radio star fading are caused by non-laminar flow, and that their non-appearance during the daylight hours may be due to the inhibition of turbulence by large temperature gradients, by lower drift velocities or by an increase in the kinematic viscosity. A.

551.510.535

Radio-wave propagation in the ionosphere. See also under "Electromagnetic waves and oscillations." Decimal classification 538.566.3

551.510.535 : 523.165

Ionosphere observations by means of 18·3 Mc/s cosmic noise. *See Abstr.* 692

551.513

1392. An elementary reasoned account of the general circulation of the atmosphere. M. J. Lighthill. *Phil. Mag.*, **45**, 1154–62 (*Nov.*, 1954).

The paper (which makes no claim to originality) gives an elementary survey of the physical causes believed to underly the more energetic features of the general circulation. The geographical distribution of temperature implies hydrostatically a strong fall of the pressure from the tropics to the poles at any fixed altitude in the upper troposphere. This produces geostrophically (in the main) the strong westerly winds found at all latitudes in that region. Simple estimates indicate why a typical wind speed is 20 m/sec. The wind distribution near the ground, a secondary effect, is intelligible only if there is everywhere a poleward flow of west-east angular momentum (taken about the earth's axis). The required flow reaches a maximum of around 3×10^{26} dyn cm, at latitude 30°. In the tropics and sub-tropics the angular momentum must flow against its own gradient. It can do so to the necessary extent, however, as a result of the poleward motions down pressure gradients in the upper troposphere which are needed to maintain the energy of the general circulation, which is dissipated at a rate of around 5×10^3 ergs/cm^2/sec. In the cyclone belt, the assumption behind this statement (that isobars in the upper troposphere lie east-west, on the whole) is constantly violated, but there the flow of angular momentum (down its own gradient) presents no difficulty, and is doubtless achieved by the cyclones themselves. A.

551.521.1

1393. Spectral distribution of energy from the sun. R. Stair, R. G. Johnston and T. C. Bagg. *J. Res. Nat. Bur. Stand.*, **53**, *No.* 2, 113–19 (*Aug.*, 1954).

Measurements on the spectral energy distribution of direct solar radiation, made in July, 1953, at Sacramento Peak, New Mexico, altitude 9200 ft, are described. Spectral data are given for wavelengths extending from 299 to 535 mμ for air masses 0, 1·0, 2·0 and 3·0. A determination of atmospheric transmittance as a function of wavelength results in calculated total amounts of ozone approximating 0·21 cm (s.t.p.) as a mean for 4 days during July. Preliminary measurements, employing a lead sulphide photoconducting cell, in the visible and infrared spectrum are discussed. On the basis of the spectral ultraviolet data obtained, an estimate of a value slightly exceeding 2·00 langleys per minute for the solar constant is indicated. A.

551.577 : 551.501.8

1394. The microwave properties of precipitation particles. K. L. S. Gunn and T. W. R. East. *Quart. J. Roy. Meteorol. Soc.*, **80**, 522–45 (*Oct.*, 1954).

The theory of scattering and attenuation by rain, snow and cloud is reviewed and theoretical results are presented in the form of equations, tables and graphs, so that the radar response to meteorological particles can be calculated at six wavelengths (10, 5·7, 3·2, 1·8, 1·24 and 0·9 cm) and various temperatures. Particular emphasis is placed on developments since Ryde's comprehensive paper in 1946. Published experimental results are compared with the theory. All results computed from the theory are tabulated.

The attenuation by water vapour and oxygen is given in an appendix. A.

551.578

1395. The development of the size distribution of raindrops during their fall. E. C. RIGBY, J. S. MARSHALL AND W. HITSCHFELD. *J. Meteorol.*, **11**, *No.* 5, 362–72 (*Oct.*, 1954).

Numerical methods are used to study the changes in the distribution of raindrops with size and in the radar echo, as rain falls. Changes brought about by collisions among the drops, by accretion of cloud and by evaporation are considered. The distribution assumed aloft is that actually observed at the ground. This is justified, because the changes in the form of the distribution are found to be slight: an exponential type of distribution law would seem to be applicable at all heights. This result is taken to mean that the processes investigated cannot by themselves produce the distributions observed at the ground from distributions of a very different sort, or from the broad distributions of snow. A mechanism as yet unknown, probably involving drop break-up, would seem to be required. The work is done both for "continuous rain," where conditions at all levels are assumed to be constant in time, and for showers, where they are assumed to be initially the same at all levels. Unequal rates of fall of raindrops tend to increase the vertical extent of the radar echo in time. The calculated rates of motion of echo top and base depend critically on range and radar sensitivity; they are in reasonable agreement with those observed. Where necessary, the rate of depletion of cloud due to rain falling through it is taken into account. A simple theory of this process, by K. L. S. Gunn (1952), is described in an appendix. A.

551.593.9

1396. Theoretical considerations regarding the dayglow. D. R. BATES AND A. DALGARNO. *J. atmos. terrest. Phys.*, **5**, *No.* 5–6, 329–44 (*Nov.*, 1954).

The measurements on the dayglow made with rocket-borne instruments are discussed critically. It is contended that the reported great altitude and great luminosity of the emissive source cannot be reconciled with the natural supposition that the phenomenon is due to direct photo-action by the incident solar radiation. An attempt is made to predict the main features of the airglow likely to result from resonant and fluorescent scattering, photo-dissociation, photo-ionization and recombination in the ionized layers. A.

551.593.9

1397. The twilight emission of sodium in the southern hemisphere. P.-N. MAYAUD AND R. ROBLEY. *Ann. Geophys.*, **10**, *No.* 3, 258–61 (1954) In French.

The great intensity of the line during the southern winter favours a seasonal variation like that found in the northern hemisphere, but opposed in phase. A.

551.593.9

1398. On the origin of sodium *D*-lines in the nightglow and twilight flash. M. OGAWA. *Sci. of Light* [*Tokyo*] **3**, *No.* 1, 47–61 (*Aug.*, 1954).

The low-pressure reactions of sodium with atomic oxygen, molecular oxygen and ozone have been investigated in order to make a laboratory check of Chapman's process of the nightglow. Sodium vapour reacts with ozone in the gas phase, accompanied only by the emission of *D*-lines which are slightly diffuse. The velocity of reaction between atomic sodium and ozone is larger than that between atomic sodium and molecular oxygen. On the basis of experimental results and in consideration of the dissociation energy of NaO, one plausible process to explain the above chemiluminescence is set forth, which differs from that of Chapman. It is impossible, however, to attempt to attribute to this process the origin of the sodium *D*-lines in the nightglow and the twilight flash in the upper atmosphere. Chapman's process would appear to be endothermic and therefore not plausible. A.

551.593.9

1399. Note on the seasonal variation of sodium *D*-line emission in twilight. D. R. BARBER. Notes *J. atmos. terrest. Phys.*, **5**, *No.* 5–6, 347–8 (*Nov.*, 1954).

Observations for 20 quiet evenings during 1949–51 are recorded using a polarization photometer. The mean zenithal intensity ratio (winter/summer) is 3·7, but the details of the variation appear to be markedly different from that observed for the nocturnal emission. J. M. HOUGH

551.594.1

1400. Observations of the electric field of the atmosphere, made at Monaco during the partial eclipse of the sun of the 20th June 1954. J. ROUCH. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 6, 465–6 (*Aug.* 9, 1954) In French.

The field was normal until the middle of the eclipse but rose to nearly twice the normal value during the second half. J. M. HOUGH

551.594.1

1401. Diffusion charging of atmospheric droplets by ions, and the resulting combination coefficients. R. GUNN. *J. Meteorol.*, **11**, *No.* 5, 339–47 (*Oct.*, 1954).

The role of ionic diffusion in electrically charging drops in the atmosphere is investigated. Space charge and chemical adsorption being neglected, exact expressions are obtained for the charging rate and the average equilibrium charge acquired by a drop in an ionized atmosphere. The augmentation of the charge by appreciable relative motion is determined. The combination coefficients for neutral and charged droplets are calculated and found to agree with direct measurements. It is concluded that ionic diffusion plays a vital role in determining the electrical equilibrium in the atmosphere. A.

551.594.1

1402. Measurements of the electrification of spheres by moving ionized air. B. B. PHILLIPS AND R. GUNN. *J. Meteorol.*, **11**, *No.* 5, 348–51 (*Oct.*, 1954).

The electrical charge transferred to highly insulated spheres by the diffusion of ions from ionized moving air is directly measured. The equilibrium charge is proportional to the logarithm of the ratio of the positive and negative ion conductivities, and depends upon the velocity of the sphere relative to its ionized environment. The measurements agree with theory. A.

551.594.12

1403. The role of eddy diffusion in the distribution of ions in the atmosphere near the ground. V. F. HESS. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 1, 51–62 (*Jan.*, 1955).

On account of α-ray emission from rocks and other soil material the ionization within the first 10 cm above ground is more intense than further up. These ions are carried upward by eddy currents until they disappear by recombination. The theory of mass exchange by eddy currents was used to compute the average number of ions present at different levels above the ground assuming the validity of Schweidler's linear recombination law for small ions. The number of α-particles emitted from the ground was determined by means of a scintillation counter (photomultiplier) for various rocks, soil materials and vegetation and it was found that the contribution of ions produced near the ground and carried upward to the 100 cm level is not negligible. It may amount to nearly 10% of the total number of ions present at this level. A.

551.594.13

1404. The disappearance of condensation nuclei in a sealed room: remarks on a paper by Smith and Schilling. P. J. NOLAN. Note in *J. atmos. terrest. Phys.*, **5**, *No.* 5–6, 345–6 (*Nov.*, 1954).

See Abstr. 5187 (1954). It is shown that the empirical relationship of Smith and Schilling can be replaced by one based on the assumption that the losses are due to coagulation, diffusion and sedimentation. Further, the numerical constants appear to be consistent with the proposed mechanism of disappearance. J. M. HOUGH

551.594.14

1405. Anomalies in the natural radioactivity of the free atmosphere. H. GARRIGUE. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 13, 776–7 (*Sept.* 27, 1954) In French.

On two occasions anomalous values have been found for the activity near the surface of the earth at different locations in France; values of 10 to 30 times the normal value have occurred and it is suggested that the cause is subterranean disturbances. J. M. HOUGH

551.594.18

1406. Aircraft investigation of the large ion content and conductivity of the atmosphere and their relation to meteorological factors, R. C. SAGALYN AND G. A. FAUCHER. *J. atmos. terrest. Phys.*, **5**, *No.* 5–6, 253–72 (*Nov.*, 1954).

Recent simultaneous measurements of electrical conductivity, large-ion concentrations, temperature and humidity in the altitude range 700 to 15 000 feet by means of aircraft are described. The results of forty flights show that over continental areas in fair weather there exists a layer adjacent to the ground varying in depth from 1000 to 10 000 feet in which the vertical distributions of charged nuclei and electrical conductivity are controlled primarily by atmospheric turbulence. At the upper boundary of this layer there is observed a sharp decrease in temperature gradient and in a transition region approximately 800 ft in depth, the conductivity is found to increase by a factor of 1·5 to 6·0; the large ion content to decrease by a factor of 1·5 to 100. Above this transition region the large ion content is reduced to very low values and the electrical conductivity increases with altitude in the same manner as determined from earlier experiments. Analysis shows that the surface layer can be identified with the friction layer familiar to meteorologists. Application of the small ion equilibrium equation shows that the destruction of small ions by collisions with nuclei is the most important factor removing small ions throughout this region. The columnar resistance of the surface layer is shown to make a significant contribution to the total resistance of the atmosphere. Observed correlations between horizontal variations in the measured electrical and meteorological variables are described and interpreted. A.

551.594.21

1407. The ion capture on polarised drops. D. MÜLLER-HILLEBRAND. *Ark. Geofys.*, **2**, *No.* 10, 197–225 (1954).

A detailed mathematical investigation of Wilson's theory of the charge acquired by a water drop moving in an electric field. Ion paths in the vicinity of the drop are calculated for both stationary and slowly moving drops; calculations are made both on the assumption that the charge is concentrated at the centre and also for the case of a surface distribution. The induction effect of nearby ions is also considered. See also abstract following. J. M. HOUGH

551.594.21

1408. Limitations of the Wilson thunderstorm theory. D. MÜLLER-HILLEBRAND. *Ark. Geofys.*, **2**, *Paper* 11, 227–44 (1954).

A critical investigation is presented of the charging mechanism of thunderclouds first suggested by C. T. R. Wilson. The relative magnitudes are determined of the charges accumulated by droplets polarized in a weak electric field and of the simultaneous diffusion process. It is argued that the Wilson process can only operate during a limited period of the life cycle of a thundercloud. It is furthermore shown that the rate of charge generation according to the Wilson mechanism is too slow and the magnitude of the charge generated too small to account for the charges involved in the mature state of a thundercloud. See also preceding abstract. R. H. GOLDE

551.594.221 : 551.501.8

1409. Radar echoes from lightning. R. F. JONES. *Quart. J. Roy. Meteorol. Soc.*, **80**, 579–82 (*Oct.*, 1954).

Photographic observations of radar echoes received from lightning are given and are used to suggest a possible distribution of the electric charge within a thunderstorm cloud. A.

551.594.5

1410. A statistical analysis of low-latitude aurorae. A. B. MEINEL, B. J. NEGAARD AND J. W. CHAMBERLAIN. *J. geophys. Res.*, **59**, *No.* 3, 407–13 (*Sept.*, 1954).

A total of 1267 aurorae, from the Yerkes Observatory records, covering a 55-year interval, have been analysed. The number per year clearly shows an 11-year cycle, having minima that coincide with minimum solar activity. The maximum of auroral

activity, however, follows the maximum of solar activity by approximately two years. A harmonic analysis, extending from 1 to 400 days, was made to examine the data for recurrence tendencies. After correction for a large-amplitude 29·5-day periodicity, due to observational interference from moonlight, a definite but very small recurrence tendency is found at 27 days. A.

551.594.5

1411. The morphology of the aurora. A. B. MEINEL. *Proc. Nat. Acad. Sci. U.S.A.*, **40**, *No.* 10, 943–50 (*Oct.*, 1954).

The more spectacular auroral displays are too complex to comprehend, but small displays have a simple form. The first phase consists of a homogenous arc parallel to the magnetic latitude. This may encircle the pole; it is not known whether or not arcs appear simultaneously in N and S polar regions. The first phase is due to extra-terrestrial protons of ½–1 MeV energy. The hydrogen emission is observed to decrease with latitude, possibly because of a mass-spectrograph action of the earth's magnetic field. The second phase is a break-up of the arc into rays and draperies. A comparison of auroral spectrograms with those produced by the bombardment of low-pressure air by various particles has shown that only electrons reproduce the auroral intensity ratio of the NII to the u.v. neg. N_2^+ bands, and further that the ratio of the Meinel N_2^+ to N_2 first pos. molecular bands fixes the energy at 400 eV. Such electrons are of too low energy to be extra-terrestrial.

W. T. BLACKBAND

551.594.7

1412. Index of refraction above 20 000 feet. M. DUBIN. *J. geophys. Res.*, **59**, *No.* 3, 339–44 (*Sept.*, 1954).

The value, based on measurements by Essen and Froome, and Barrett, is considered for a wide range of radio frequencies. To an accuracy of one part in a hundred thousand, the density of air alone is of importance, and to an altitude of only 26 km. Effects from water vapour, and electron concentrations in the ionosphere for frequencies of 5000 Mc/s, were found negligible to the accuracy indicated. A.

BIOLOGY 57/59

578.088.5

1413. An apparatus giving an α-particle microbeam for the irradiation of living cells. H. A. B. SIMONS. *J. sci. Instrum.*, **32**, *No.* 1, 21–4 (*Jan.*, 1955).

A microscope fitted for phase-contrast observation is modified so that a biological specimen in the centre of the field of view may be irradiated with α-particles. A beam of α-particles is obtained from a polonium source by a glass capillary collimating tube of 15 μ internal diameter, the source and collimator being mounted in a tube passing axially through the optical condenser. The irradiation rate is of the order of 1 particle/min and 70% of the particles lie within a circle of 30 μ diameter in the focal plane of the objective. A statistical method is used to calculate the probability of irradiation of a target of known size which is irradiated for a known time. A.

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612.171.1

1414. An integrating and differentiating bar-magnet velocity meter for use in ballistocardiography. T. A. PERLS AND C. W. KISSINGER. *Rev. sci. Instrum.*, **25**, *No.* 10, 983–8 (*Oct.*, 1954).

An integrating and differentiating bar-magnet velocity meter is described. Design criteria are presented for integrators and differentiators to meet given specifications of frequency response. In the design of the differentiator, use is made of a small amount of resonance magnification in a suitably damped series-resonant circuit. Test procedures are described for determinations of frequency response, sensitivity, and linear range of the instrument. Examples are given of sensitivity adjustment and installation procedures for use of this instrument in ballistocardiography. A "60 c/s Hum Compensator" is used to cancel out any objectionable 60 c/s pickup from the power line. A.

612.843.14

1415. A new method for determining the absorption spectrum of visual purple. E. J. DENTON. *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 20, 1315–16 (*Nov.* 15, 1954) In French.

A method previously described [*J. Physiol.*, **124**, 16P (1954)] was used to examine the dichroism of Salamander retinae. There is a marked spectral variation, due essentially to the orientation of the visual pigment molecules in the receptor end-organs. The bleached products exhibit a dichroism opposite in sign to that of the unbleached pigment. While the spectral variation of the dichroism of the unbleached retinae closely follows the absorption spectrum of visual pigment 502, there is no similar correspondence between the bleached preparations and the corresponding decomposition products.

R. A. WEALE

612.843.611

1416. Variability of measurements of human dark adaptation. F. A. MOTE. *J. Opt. Soc. Amer.*, **45**, *No.* 1, 7–12 (*Jan.*, 1955).

Data on the dark adaptation of three subjects were gathered. All were given the same pre-exposure and testing conditions and threshold measurements taken for 40 min at each experimental session. Each subject served in 12 sessions spread over a period of 11 months, and two dark adaptation curves were obtained at each session. The effect of obtaining two curves per session, morning *v.* afternoon conduct of the sessions, and of changing experimenters was investigated, and, except for one minor difference, no

statistically significant effect was found to result from these factors. The data showed that the variability of threshold measurements changed during the course of 40 min dark adaptation. It began at a given value and declined in magnitude toward the end of cone adaptation. At the time of the cone-rod transition the variability of two of the subjects showed a marked increase and it remained at a relatively high level for several minutes, gradually becoming smaller. After about 20 min the variability reached a minimum stable value and stayed around this value for the remainder of dark adaptation. An explanation is offered to account for this result. Another result was that the magnitude of the variability showed inconsistent changes during the progress of the experiment, brought about by aberrant curves that were obtained from time to time. There seems to be no ready explanation for the occurrence of such curves. A.

612.85 : 534.321.7

1417. Time factors in relative and absolute pitch determination. A. BACHEM. *J. Acoust. Soc. Amer.*, **26**, *No.* 5, 751–3 (*Sept.*, 1954).

Error measures of pitch discrimination were obtained as a function of the time lapse between standard and comparison tones. The time interval ranged from one second to one week, establishing a "curve of forgetting." Half of the subjects possessed absolute pitch. Results indicate that for short time intervals there is no observable difference in pitch discrimination between the two groups of subjects. With longer intervals there is a decided discrepancy, so long as the tone is within the musical range. This discrepancy in time-error curves is attributed to the shift from relative pitch comparison to chroma identification by those subjects possessing absolute pitch. The lack of discrepancy at the upper border of the musical frequency scale is attributed to chroma fixation. The curves of forgetting are more sigmoidal than straight logarithmic, particularly in the case of absolute pitch. A.

612.858

1418. Exploration of cochlear potentials in guinea pig with a microelectrode. I. TASAKI, H. DAVIS AND D. H. ELDREDGE. *J. Acoust. Soc. Amer.*, **26**, *No.* 5, 765–73 (*Sept.*, 1954).

The a.c. ("microphonic") cochlear potential and the positive d.c. "endolymphatic" potential have been recorded simultaneously as the exploring electrode was introduced into scala media or as other parameters were varied. Negative intracellular d.c. potentials were demonstrated in the cells of the organ of Corti. The zone of positive endolymphatic potential is bounded by the reticular lamina, not by the basilar membrane. The cochlear microphonic reverses phase as the exploring electrode penetrates the reticular lamina. A d.c. polarizing current with the positive pole in scala media (and negative in scala tympani) increases the cochlear microphonic just as it does when the positive pole is located in the scala vestibuli. These facts indicate that the source of the a.c. (microphonic) potential seems clearly to be at the hair-bearing end of the hair cells and that the source of the d.c. endolymphatic potential is probably here also, while Reissner's membrane is not the source of either the a.c. or the d.c. potential. No steady d.c. current flow outside scala media was found such as would be expected if stria vascularis were the d.c. source and if the hair cells modulated a d.c. current flow through them. The d.c. endolymphatic potential may be increased by as much as 10% if and while the basilar membrane is displaced toward scala vestibuli and may be decreased to 50% or less when and while it is displaced toward scala tympani. Isotonic solutions rich in potassium depressed the a.c. potential and nerve responses when introduced into scala tympani but not when in scala vestibuli only. The d.c. potential, however, was not altered by high potassium concentration in scala tympani. A.

612.858.71

1419. Hearing losses of aircraft repair shop personnel. J. C. WEBSTER. *J. Acoust. Soc. Amer.*, **26**, *No.* 5, 782–7 (*Sept.*, 1954).

614.898

1420. Techniques used for protection of personnel likely to be irradiated by α- and γ-rays and by thermal and slow neutrons. P. SAVEL. *J. Phys. Radium*, **15**, *No.* 10, 113 A–118 A (*Oct.*, 1954) In French.

Methods used by the author for measuring γ-ray exposure of personnel by means of film badges are discussed. A spark counter is described (circuit given) which will detect α-particles of intensity less than "tolerance" and can also be modified to differentiate between stray α- and γ-radiation, thermal and slow neutrons. D. V. MABBS

615.849

1421. Dosage determination for rotation therapy in the horizontal plane. E. H. QUIMBY, V. CASTRO AND C. SOIFER. *Radiology*, **63**, *No.* 2, 201–19 (*Aug.*, 1954).

An approximate method of calculating dosage distributions for "convergent beam" therapy, using circular fields 4–7 cm dia., with and without wedge filters is described. The results are shown to agree with rigorous calculations [Green, Jennings and Bush, *Acta Radiologica* [*Stockholm*], **31**, 273–320 (1949)] within about 10% and also with measurements using condenser chambers to the same degree. Some typical treatment plans are given, as well as details of wedge filter and wax cone design. F. T. FARMER

615.849.1 : 535.343 : 537.531

Spatial distribution of energy dissipation by high-energy X-rays. *See Abstr.* 978

616–073.75

1422. The use of radioactive isotopes for diagnostic radiology. G. E. DENNIS AND H. A. DELUCA. *Amer. J. Roentgenol.*, **72**, *No.* 4, 661–5 (*Oct.*, 1954).

A number of examples are given of the use of a source of 5 curies of thulium-170 and two sources of cerium-144, of 150 millicuries and 15 curies respectively, to produce radiographs of bony structures. A discussion is given of the use of radioactive isotopes for medical radiography. None of the materials so far investigated is ideal in all respects. It is concluded that kilocurie sources will be necessary for this work. H. MILLER

TECHNIQUE. MATERIALS 62/69

669

1423. A method of stretching thin aluminum foil over large areas. P. C. MURRAY, C. A. TATRO AND R. O. HAXBY. Letter in *Rev. sci. Instrum.*, **25**, *No.* 9, 924 (*Sept.*, 1954).

Foils of 0·001 in. thickness were bonded across the openings of up to 4 in. diameter glass cylinders and 10 in. square steel frames. The foil and former are first heated to 1700°C, then Araldite is applied as cement and the cement set by slow cooling of the whole to about 170°C. S. WEINTROUB

PHOTOGRAPHY 77

77.023.4

1424. An evaluation of film speeds obtained with Kodak SD-19A developer. P. HARIHARAN. *J. Opt. Soc. Amer.*, **45**, *No.* 1, 60–2 (*Jan.*, 1955).

Experimental results are presented which show that even though Kodak SD-19A developer can produce a substantial increase in the fractional gradient speed of typical high-speed, panchromatic negative films, this increase is not reflected in speed measurements based on a resolving power criterion, except at very low values of resolution. A.

771.53

1425. Influence of irradiation by red light on the adsorption of developer oxidation products on binder-free silver bromide. E. BRAUER AND H. STAUDE. Note in *Naturwissenschaften*, **41**, *No.* 15, 364 (1954) In German.

In connection with the mechanism of latent image formation, it has been shown that after adsorption of quinone on illuminated AgBr, red light causes partial desorption and conversion of a little to hydroquinone. Subsequent illumination with white light causes readsorption of quinone. S. T. HENDERSON

771.53

1426. Photographic plate with constant contrast. M. SLAVIN. Letter in *J. Opt. Soc. Amer.*, **44**, *No.* 9, 746 (*Sept.*, 1954).

Proposals are made for an extension of the region of nearly uniform contrast in the fluorescence-sensitized u.v. spectrometry plate described in Abstr. 6359 (1953).

771.533 : 535.345

Spectral absorption in photographic emulsions. *See Abstr.* 853

771.534

1427. Reciprocity law failure in desensitized emulsions. S. TUTIHASI. *J. Opt. Soc. Amer.*, **45**, *No.* 1, 15–18 (*Jan.*, 1955).

The reciprocity law failure of desensitized emulsions has been studied in the range of the moderate and extremely high-intensity exposures. It is shown that in the desensitized emulsion some of the decreased efficiency associated with normal saturation effects is removed in the high-intensity range relative to the nondesensitized basic emulsion. Two of the three dyes studied have shown two steps of low-intensity reciprocity failure: a strong, primary low-intensity failure and a weak, secondary failure. Speculations on the mechanisms of these two failures are given. A.

771.534.5

1428. Effect of ionic conductivity on deviations from reciprocity law in photographic emulsions. A. L. KARTUZHANSKIĬ. Letter in *Zh. éksper. teor. Fiz.*, **26**, *No.* 6, 763–4 (1954) In Russian.

Meiklyar [*Uspekhi fizicheskikh Nauk*, **38**, 43 (1949)] showed that the period of neutralization of an electron after its fixation is given by $t_n = \varepsilon/2\pi\sigma$, where σ is the specific conductivity, and ε — permittivity. This gives $t_n \sim 10^{-5}$ sec for AgBr, in agreement with the experimentally determined limit of applicability of the reciprocity law in AgBr emulsions. Deviations from this law were investigated [for method cf. Abstr. 8412 (1951)] for 4 positive emulsions containing the following AgCl/AgBr ratios: 100/0, 25/75, 10/90 and 0/100. It was found that the rectilinear portion of the iso-opacity curve moved more and more to longer exposures as the proportion of AgCl increased, in agreement with its lower conductivity compared with AgBr. The t_n values for the 4 emulsions were calculated from specially determined σ values and known ε values; the t_n values ranged from 6×10^{-4} to 1×10^{-5} sec. F. LACHMAN

772

1429. Self-luminous halftones. F. A. SCHWERTZ, M. N. HALLER AND J. J. MAZENKO. Letter in *J. Opt. Soc. Amer.*, **44**, *No.* 9, 745–6 (*Sept.*, 1954).

A xerographic picture on Se is prepared with an electroluminescent powder which is then transferred electrostatically to a thin layer of PVC on conducting glass. The phosphor layer is fixed by heating and coated with evaporated Al to form an electroluminescent cell which reproduces the original halftone when excited. S. T. HENDERSON

778.33 : 539.16

1430. Thulium 170 for industrial radiography. R. HALMSHAW. *Brit. J. appl. Phys.*, **6**, *No.* 1, 8–10 (*Jan.*, 1955).

The use of Tm^{170} for industrial radiography has been investigated. The exact nature of the γ-ray spectrum does not appear to be agreed and the absorption curves which have been obtained suggest the presence of some high energy radiation, probably due to bremsstrahlung. Exposure curves for steel and aluminium are given and a sensitivity-curve for step penetrameters is derived. The values calculated are compared with experimental values using step and wire penetrameters and with radiographs taken with Ir^{192} and X-rays. The suitability of intensifying screens is discussed and some possible applications of Tm^{170}, taking into account the low activity of present sources, are suggested. A.

778.34

1431. Measurement of the shrinkage of nuclear emulsions. M. GAILLOUD, C. HAENNY AND R. WEILL. *Helv. phys. Acta*, **27**, *No.* 4, 337–54 (1954) In French.

Ilford C2 100 μ, C2 200 μ B, C2 100 μ Li and G5 100 μ emulsions were irradiated with a well-

defined α-particle beam at a known angle of incidence ϕ_0, and the apparent angle of incidence in the processed emulsions measured, to determine shrinkage factors. The irradiation was carried out at 20° ± 1°C and 56% rel. humidity, and the humidifying for observation at 25° ± 0·1°C and 51% r.h. Special precautions were taken, during development, fixing and drying, to ensure minimum swelling and distortion. The values obtained were 2·75 for G5 100 μ, 2·88 for C2 100 μ, 3·31 for C2 100 μ Li, 3·09 for C2 200 μ B, the error being less than 2%. These values agree with those obtained, much less exactly, by thickness measurement. The indices of refraction of the fixed and washed emulsions were also measured, in equilibrium with atmospheres of various humidities, to determine the true shrinkage factor. The authors are satisfied that, under the given experimental conditions, the shrinkage factor remained the same for angles different from that chosen (40°). Previous shrinkage measurements are reviewed.

778.34

1432. Note on the loading of photographic emulsions with wires. A. H. MORRISH. Note in *Rev. sci. Instrum.* **25**, *No.* 8, 831–4 (*Aug.*, 1954).

Discusses a technique for loading emulsions with wires of diameter 25 to 50 μ and ribbons up to 250 μ wide. Metals such as Cu and Al which react with the emulsion are first coated with shellac or enamel. In order to eliminate distortion due to shrinkage, the emulsion is soaked in a rosin–alcohol solution after washing. Some example of applications of the technique are given. P. ROTHWELL

778.34

1433. Preparation of emulsion chambers suitable for quick tracing of all tracks. J. OREAR. Letter in *Rev. sci. Instrum.*, **25**, *No.* 10, 1023–4 (*Oct.*, 1954).

Discusses technique whereby light tracks may be followed with certainty from one emulsion layer to the next. To ensure that two surfaces, originally in contact, are lined up, small bits of fine wire are pressed between successive layers to produce identically shaped marks on the adjoining surfaces. To preserve dip and azimuth angle, the pellicles are processed and dried while still unmounted; details of this procedure are given. The distortion with depth is negligible, but there is a small lateral distortion. This is not serious provided the pellicles can be lined up every few millimetres along the way, using heavy tracks which pass through. P. ROTHWELL

778.34 : 539.172.4

1434. On the use of nuclear research emulsions with embedded wires. E. G. SILVER AND R. W. WANIEK. *Rev. sci. Instrum.*, **25**, *No.* 11, 1119–23 (*Nov.*, 1954).

The importance of determining the nucleus involved in a specific interaction within a nuclear research emulsion is discussed, and the technique used to embed thin filaments in these emulsions is described in detail. The usefulness of this method is illustrated by an experiment in which nylon, molybdenum and tungsten wires were embedded in Ilford G5 emulsion, and the plates subsequently used to study neutron induced interactions. The uncertainties encountered and the corrections introduced in this method are analysed. A.

778.34 : 539.18

1435. Photo-electric mass determinations in nuclear emulsions. I. An investigation of the accuracy of mass determinations. K. KRISTIANSSON. *Ark. Fys.*, **8**, *Paper* 31, 311–31 (1954).

An investigation is described of the accuracy of mass determinations of singly charged particles ending in a nuclear emulsion. The standard deviation amounts to 10% of the mass for protons with a residual range of 4000 microns. The greater part of this error is due to extended irregularities in the emulsions. The mass of an unknown particle can be determined with higher accuracy through a suitable choice of known particles for comparison. A.

778.34 : 539.18

1436. Photo-electric mass determinations in nuclear emulsions. II. A new correction for local variations in the emulsion with a report on the photo-electric identification of *K*-particles. S. VON FRIESEN. *Ark. Fys.*, **8**, *Paper* 30, 305–10 (1954).

A correlation has been shown to exist between the density of the general background in a nuclear emulsion and the photoelectrically determined mass values of protons in the same region, by means of which it will be possible to improve the mass determinations of particles of unknown mass. In the course of the work *K*-particles have been found which show neither decay nor visible interaction at the end of their range. A.

778.34 : 539.18

1437. Photo-electric mass determinations in nuclear emulsions. III. Description of the new experimental arrangements. S. V. FRIESEN AND L. STIGMARK. *Ark. Fys.*, **8**, *Paper* 9, 121–7 (1954).

778.34 : 539.18

Life time measurements of unstable charged particles using emulsions. *See Abstr.* 1233

778.37

1438. A method of identifying double-flash exposures. N. DOMBROWSKI. *Brit. J. appl. Phys.*, **6**, *No.* 1, 17–18 (*Jan.*, 1955).

A method is described of identifying two exposures taken in rapid succession on one photographic plate. It employs two light sources of differing spectral constitution with two plates, face to face, of suitable colour sensitivities. By this means a reference negative containing one image is obtained, in addition to the usual double-flash photograph. A.